An Illustrated Anatomy of the World's

FIGHTERS

The inside story of 100 classics in the evolution of fighter aircraft

Superbly detailed cutaway drawings of 100 types of fighter: from the World War I Morane-Saulnier Type N to today's high-performance McDonnell Douglas F-18 Hornet

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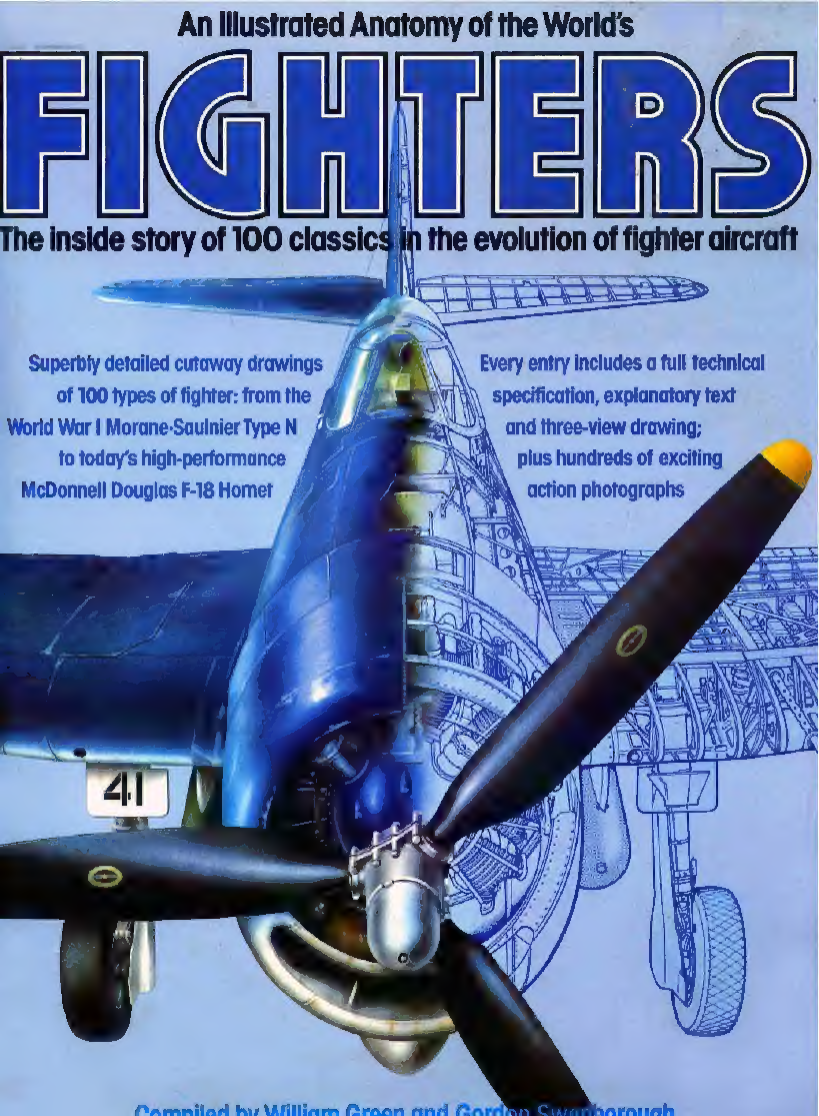

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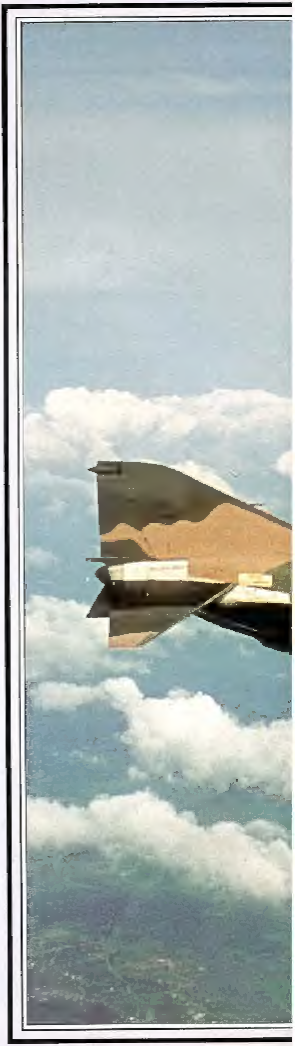

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The Compilers

William Green
William Green entered aviation journalism early in World War II with the *Air Training Corps Gazette* (now *Air Pictorial*) and has gained an international reputation for his many works of aviation reference, covering both aeronautical history and the current aviation scene. Following RAF service, he was European correspondent to US, Canadian and South African aeronautical journals and British correspondent to several European publications. He was Technical Director to the RAF *Flying Review*, then Editorial Director when it became *Flying Review International*. In 1971 he and Gordon Swanborough jointly created the monthly *Air International* now one of Europe's foremost aviation journals, and they have also produced a number of books under joint authorship.

Gordon Swanborough
Gordon Swanborough has spent his working life as an aviation journalist and author, with the exception of a year-long appointment in 1954 as a Sales Publicity Officer with the British Aircraft Corporation. From 1943 until 1953 he was a member of the editorial staff of the weekly magazine *The Aeroplane*, specialising for much of that time in air transport affairs. In 1955 he became editor of *Flying Review International*, and in 1971 joined forces with William Green to create *Air International*. As a team, these two authors are also responsible for the production of the thrice-yearly *Air Enthusiast*, devoted exclusively to aviation history, and the annual *RAF Yearbook* as well as a series of authoritative works on both current aircraft and various aspects of aeronautical history.

Preface

Since the first aircraft intended for aerial combat per se climbed into European skies almost seventy years ago and the term *scout* took on the connotation of *fighter*, the speeds attainable by such warplanes have increased from less than 100 to more than 1,500 miles per hour; their ability to climb from sea level has risen from less than 1,000 to more than 60,000 feet per minute; fuel capacities have grown from less than a dozen to several thousand gallons, and maximum take-off weights have soared from fewer than 1,000 to as much as 100,000 pounds. The purpose of this book is to portray this dramatic evolutionary process by means of detailed cutaway drawings illustrating the structures, systems and equipment of the most important fighter aircraft to have achieved service since the birth of the genus.

Such has been the prolificity of succeeding generations of fighter designers in their attempts to achieve an advance in the state of the art that our selection of aircraft types to portray fighter evolution has been perforce arbitrary. Some of the aircraft illustrated on the pages that follow may assuredly be described as classics in that they established new standards that others endeavoured to emulate; some were outstandingly successful without being classics, and yet others, perhaps as a result of short-sightedness on the part of their designers, ineptness on the part of those responsible for framing the requirements for which they were conceived, or inadequacies in the engines available to power them or weaponry available to arm them, were somewhat less than successful. Each had its own significance, nationally or internationally, however, and played its role in the development of the fighter category.

Space considerations have, at times, dictated selection of but one from a group of equally deserving warplanes to portray a particular aspect of the evolutionary process. A case in point is provided by inclusion of the Reggiane Re 2001 to represent an entire generation of Italian fighters when such as the Macchi C.205 and Fiat G.55 were equally efficacious. Thus, this book is a synopsis of the history of fighter development rather than an attempt to chronicle the evolution of the species in depth. An attempt has been made to place each type in its context—the aberrations from the mainstream of fighter evolution, such as the rocket-driven Me 163, are few—and the aircraft appear in chronological sequence of their début in prototype form, their backgrounds and histories being briefly related and specifications being provided for comparison purposes.

The definition of *fighter* has undergone metamorphosis over the years, a process that has accelerated in the past two decades. Whereas a fighter was once defined as an aircraft primarily designed to intercept and destroy other aircraft, such tasks as ground attack being purely fortuitous and very secondary to its primary air-air role, WWII saw examples of a secondary role taking precedence, although air-air capability was retained, the Typhoon providing an outstanding example. This development became ever more pronounced in the post-WWII years, with the use of the term *fighter* becoming increasingly generic until it embraced a wide variety of loosely related aircraft types, varying tremendously in primary role, performance capability and size.

The adoption of the wider definition of the fighter classification is reflected in this book by the inclusion of such aircraft as the Harrier and F-111, which cannot be considered as fighters in the traditional sense. Today, a fighter may be categorised as multi-role, its mission spectrum ranging from air superiority and interception to deep penetration strike and counterair activities. Alternatively, it may be optimised for specific tasks such as ground attack, its air-air capability being confined to—what is in some cases a rather dubious—self-defence potential, and its likely use against other aircraft in the *traditional* fighter sense is remote. All the aircraft appearing on the following pages are *categorised* as fighters, but the reader may well find himself asking "When is a fighter a fighter?"

WG and FGS

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The History of the Fighter

by Roy Braybrook, one of Britain's leading freelance writers and consultants on military aviation. His previous appointments include Senior Project Engineer with Hawker Aircraft, and Technical Marketing Advisor to the Kingston-Brough Division of British Aerospace.

Under an agreement reached at the Hague Conference of 1899 (only to be rescinded at a similar conference in 1907), the discharging of projectiles or explosives from any aerial machine was banned, just as more recently the nations of the world have agreed not to place nuclear weapons in space vehicles.

At the time that they made their first powered flights in December 1903, the Wright brothers, far from regarding the aeroplane (or "Flyer", as they called it) as a potential weapon of war, dreamed that they were introducing an invention that would make further wars practically impossible. There was no way they could then foresee that aircraft would play a major role in future wars, or that fighters (ie, aircraft dedicated specifically to aerial combat) would lead to the growth of powerful manufacturing companies, with production lines many times the length of their Flyer's initial hops into the air.

Nor could Orville Wright, in discussing the aerial warfare being waged over France in World War I, have foreseen how military aviation technology would develop. Today, supersonic interceptors powered by gas turbine engines and flown largely by black boxes can engage multiple targets beyond visual range by launching miniature, unmanned, rocket-powered aircraft, guided by inertial systems, radar, or infra-red homing. Such weapon systems are the products of many advanced technologies, all undreamed of in 1917 when Orville wrote, "What a dream it was; what a nightmare it has become".

After all this progress, fighter development continues, although (as in the Wright brothers' day) the pace of advance is restricted by the funds available, which, in turn, are a function of political priorities.

We can, however, look ahead a little way. We can anticipate a generation that will combine supersonics with V/STOL capability, and fighters that will cruise supersonically for extended periods, rather than making a brief dash before the fuel runs out. The hypersonic interceptor is technically feasible, although currently its military priority is low. The "Stealth Fighter" is sure to come, its reduced radar- and IR-signatures making it the modern equivalent of a WWI experiment in which one manufacturer tried to produce an invisible aircraft by giving it a covering of cellulose rather than fabric.

In terms of fighter armament, we know that "death rays" in the form of directed energy weapons (high energy lasers and particle beam devices) are only waiting on the development of lightweight "guns". Armament that today is aimed by a crude gunsight or head-up display (HUD) will soon be directed at offset targets by helmet-mounted sights, or possibly by movement of the pilot's eyes, and fired by voice command. Missiles are already under development to enable conventional supersonic fighters to engage satellites in orbit. Tomorrow, star wars?

Early beginnings

Following on from earlier military use of the balloon and dirigibles (observation balloons were first used in the Battle of Fleurus in 1794, and subsequently in the American Civil War, the Franco-Prussian War and the Boer War), the aircraft was initially seen by army staffs purely in a reconnaissance context. It was on this basis that in 1908, the US Army purchased for $25,000 a two-seat Wright biplane, which crashed in the course of demonstrations. However, its replacement was officially designated: "Aeroplane No 1, Heavier-Than-Air Division, United States Aerial Fleet".

The US Army also took the lead in experiments with various types of armament on aircraft, although France and Germany were soon to replace America in the military application of aviation. The first firearm to be fired from an

aircraft in flight was a rifle discharged by Lt Fickel of the US Army, flying in a Curtiss biplane near New York in August 1910. Also during that year, the German engineer Euler took out a patent on a machine gun installation for an aircraft, the Voisin company exhibited a two-seat pusher biplane armed with a *mitrailleuse* at the Paris Salon, and radio signals were transmitted from a Farman aircraft during British Army manoeuvres.

The year 1910 also witnessed the first take-off from a ship, when, on 14 November, Eugene Ely flew a Curtiss biplane from a platform on the forward deck of the cruiser USS *Birmingham*. However, it was not until the following 18 January that the first landing on a ship took place. Ely putting the Curtiss down on a platform over the stern of the USS *Pennsylvania*, to be brought to a stop by three arrester hooks on the landing gear engaging with ropes attached to sandbags. That same month saw the first bomb dropped, in a trial near San Francisco using a Wright biplane.

That year of 1911 was to be an important one for military aviation, since aircraft were used in war for the first time. Visual reconnaissance, aerial photography and bombing (strictly speaking, grenade-dropping) missions were flown by Italian aircraft near Tripoli in North Africa, the first operational sortie of this Italo-Turkish War taking place on 23 October 1911. Also during that year, a machine gun was fitted experimentally to a Nieuport two-seater in France and to a Bleriot monoplane in England. Equally significant, 1911 signalled the appearance of the Gnome rotary, often regarded as the first true aero-engine.

The first firing of an automatic weapon from an aircraft in flight occurred on 2 June 1912, when a Lewis gun was fired from a US Army two-seat Wright B biplane flying over Maryland. However, the US Army decided against adoption of the weapon, so Col Isaac Newton Lewis formed a company in Liege, Belgium, to manufacture it. The Lewis gun became the standard light machine gun of the Belgian and British armies, and was to be used extensively as an aircraft armament, even by the US Army Air Service. For aircraft use, it had the advantage of being moderately light and reliable, and of being fed from drum-type magazines (initially housing 47 rounds and later 94), which made it more suitable for flexible mountings than belt-fed guns.

The Sopwith Camel (**opposite top**) was one of the most manoeuvrable fighters of WWI, but, as related on page 42, it was an unforgiving aeroplane. Its primary significance lay in the fact that it was the first British service fighter with twin synchronised guns. The intended successor of the Camel, the Snipe (**opposite bottom**) began to appear in service in the summer of 1918, its first patrol being performed (with No 43 Sqdn) on 29 September of that year. Retaining much of the rapscallionness of its predecessor, the Snipe was not considered to possess wholly satisfactory control response when it arrived in France, but it nevertheless remained the RAF's standard single-seat fighter well into the twenties, being finally withdrawn in 1927. Contemporaneous with the Morane 'Bullet' (see page 34) and thus one of the first of the fighter genus, the Fokker monoplane had a dramatic effect on the air war over the Western Front in 1915. The Fokker E II (**above**) represented an attempt to optimise the basic monoplane design for the offensive role. Armament comprised a single synchronised one-calibre machine gun. As the popularity of the monoplane configuration waned, Fokker concentrated on the biplane for his next series of fighters, the D II (**right**), seen in German Navy service, being built in both single- and two-bay forms. The D II failed to emulate the success that had been enjoyed by the Fokker monoplanes when it arrived at the Front in July - August 1916.

[illegible] **above** [illegible] **left** [illegible] **opposite top** [illegible] **far right** [illegible] **right** [illegible]

During 1912, the Lewis gun was demonstrated on a Henri Farman biplane over Laffan's Plain near Farnborough, but at that stage there was no interest on the part of Britain's War Office. The same year saw the first take-off from a moving ship when in January the Royal Navy's famous pioneer pilot Lt G.R. Samson flew a Short S.27 biplane from a platform on the battleship HMS *Hibernia* while the vessel was steaming at 10½ knots (19.5 km/hr).

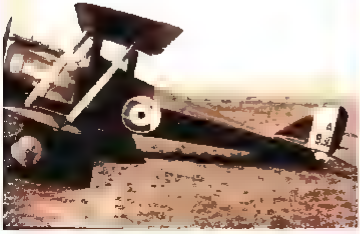
Prior to this time many small aircraft had been monoplanes. For example the French military aircraft competition (Concours Militaire) of 1911 had been won by a Nieuport monoplane, carrying a 660-lb (300-kg) load over a 187.5 mile (300-km) course at an average speed of 73.1 mph (117 km/hr). However, following a series of fatal accidents, on the British side, six pilots of the newly-formed Royal Flying Corps were killed in the course of a few weeks in Nieuport, Deperdussin and Bristol monoplanes. In May 1912 the British and French military authorities announced a ban on monoplanes; a ban that was to stay in force almost until the outbreak of WWI.

Aside from the dictates of the authorities, one of the principal factors affecting the configuration of an armed aircraft was the need to separate the propeller disc and the machine gun's line of fire. Just prior to the war, patents were applied for by various inventors to enable an automatic weapon to fire through the propeller disc, but little had been done to put these 'interruptor gears' into practice.

Designers in the period immediately before WWI thus concentrated on pusher layouts such as those of Henri and Maurice Farman and the Vickers EF8.1 which led to the FB.5 Gunbus of 1914. However, the armed services of the Great Powers still regarded the aircraft primarily as a means of extending their field of view and hence purchased them simply as two-seat reconnaissance platforms. In the UK Vickers was left to build 50 Gunbuses as a private venture, anticipating that a demand for armed aircraft would arise on the outbreak of the war that many considered inevitable.

World War One

During the early weeks of the war there was no real sense of combat, partly because the aircraft available were not equipped for it. On ferrying their aircraft to France, the



pilots of the four RFC squadrons were told that 'in the event of meeting a Zeppelin they should ram it'. Aside from lack of armament, there was also a feeling that aviation was somehow divorced from actual combat: pilots on both sides sharing the comradeship of the air rather than being divided by the conflict between nations. However, such feelings changed with the German victory at Mons on 24 August 1914. Before the end of the month the first airman (a pilot of No 5 Sqn, RFC) had fired his revolver at an enemy aircraft. Aerial combat had begun.

Although the role of the scouts was still to watch and photograph enemy movements and to direct artillery fire, they thus began to be armed with rifles, with which the observers would engage enemy aircraft. At this stage most scouts were not powerful enough to mount a machine gun and still retain a reasonable performance. However, fitted with a 150 hp engine, Germany's Albatros C I managed to combine firepower and performance and set the pattern for two-seat scouting aircraft for the remainder of the biplane era. Whereas previously the observer had been placed ahead of the pilot for forward view and to minimise the required CG range, the Albatros C I had the observer in the rear cockpit to provide the best possible field of fire. He was armed with a 7.92-mm Parabellum LMG 14 (*Luftgewehr*, *Maschinengewehr*, or aircooled machine gun) on a Schneider ring mount, and later in the war the series was fitted with a synchronised forward-firing Spandau LMG 08/15 of the same calibre.

The appearance of the Albatros C I in early 1915 thus represented the solution of the armament problem for the two-seater, but for the single-seater the basic incompatibility of the propeller and the machine gun remained. Typical of the early experiments, several aircraft (including the Bristol Scout C) were fitted with a Lewis gun angled off to the side to fire outside the propeller disc. However, this called for beam attacks with the aircraft flying on parallel courses and was virtually useless against anything but a completely docile target.

A more practical scheme was tried in the case of France's Morane-Saulnier L, a parasol-wing aircraft that had entered service in 1913. A machine gun was mounted above the wing, firing elevated above the line of flight to miss the

propeller. This gave the pilot more opportunity to approach his quarry unseen (ie, from below the tail or what would now be termed the low six o'clock position). However, for a manoeuvring target, there was no substitute for a gun firing along the line of flight. Since a pusher arrangement (as in the Vickers Gunbus) led to a loss of propeller efficiency, and consequently an unacceptably low performance, the development of an effective single-seat fighting scout depended on the development of a reliable interruptor gear. A means had to be found by which the action of a forward-firing, engine-mounted machine gun could be synchronised with the movement of the propeller.

Just before the war, Raymond Saulnier of the Morane-Saulnier company had been experimenting with a system to synchronise the rotation of the propeller with the firing of a mitrailleuse, using both a Hotchkiss and Saint-Etienne types. However, the system did not work very well, and the 8-mm cartouches tended to hang-fire, so Saulnier fitted steel deflector plates to the blades. This clearly did nothing to improve their efficiency, but eliminated the possibility of damage from the soft (copper-jacketed) bullets.

[illegible] **left**, which entered service in May 1916. [illegible] the [illegible] wrappers was made by the [illegible]

Immediately above: [illegible] Pr[illegible] being [illegible] the [illegible] [illegible] 1917 [illegible] 7 was [illegible] The Spad[illegible]

Head of page: [illegible] had lost its edge with the appearance of faster more heavily armed adversaries, although he [illegible] was astonished to some treasure [illegible] This was for [illegible] and [illegible] speed. **Right**: the author [illegible] the [illegible] over the western [illegible] 918

With the urgent practical demands of war the Saumier system of synchronisation was abandoned, but the steel deflector plates were fitted to the blades of a Morane L monoplane. Operational evaluation of the scheme was carried out by the company pilot Roland Garros, who succeeded in shooting down five enemy aircraft in April 1915, before being forced to land behind the German lines.

Although this "secret weapon" had been lost to the enemy, it was of no direct use to the Germans, since the deflector plates were incapable of protecting propeller blades against steel-jacketed Parabellum ammunition. Tasked with developing an alternative system, the Dutch designer Anthony Fokker (then working in Germany) took as his basis a concept patented by Franz Schneider in 1913. This had already been fitted experimentally to a two-seat LVG (made by the company for which Schneider worked), but the aircraft had crashed while being delivered for operational trials. Fokker fitted an interruptor gear to his M5K *Eindecker* (monoplane) and demonstrated it to the German authorities, firing Parabellum LMG through the propeller. The aircraft was put into production as the Fokker E I, in which Max Immelmann made his first kill with a synchronised weapon on 1 July 1915. Others who won fame in the days of the "Fokker Scourge" were Oswald Boelcke and Ernst Udet.

Although undoubtedly one of the most important fighters historically, the Fokker E-series were not outstanding as flying machines. When the E I was pitted against the Morane-Saulnier N in every respect, in addition, the interruptor gear was far from perfect, sometimes shooting off the propeller. Nonetheless, the Fokker monoplane gave Germany an superiority until August 1916 when a new generation of British and French aircraft arrived at the front, some equipped with synchronised forward-firing guns.

As the single-seat fighting scout became a practical proposition, the various air arms began to develop tactics and formations that would minimise their losses and simultaneously maximise their kills. The Allies took the lead in the use of defensive formations of two-seaters, providing mutually protective fire. However, the accuracy of the observer's gun was inevitably less than that of the fighter firing along its line of flight.

Formations were arranged to be close enough for hand-

[illegible] **right**, stunned [illegible] **above left**, and the [illegible] **left** [illegible] 700 [illegible] planes were produced

signalling in to a very elaborate ritual involving rolls to hold station, yet spaced sufficiently to avoid collisions. They had to provide security for all the aircraft and allow safe turning. Since a dive out of the sun into the six o'clock position was the best form of attack (combining a high overtaking speed with reduced chance of detection), a defensive formation would be stepped up down sun to give each aircraft a clear view of the probable direction of attack. This also ensured that the up-sun aircraft was protected by aircraft with more height, which could be converted into speed in coming to its aid. In the course of formation development the leader, who was also responsible for navigation, came to fly on the up-sun side, since this was where most attention was concentrated, and hence his signals (by hand or wing wagging) could readily be seen.

In the development of offensive formations, Boelcke is said to have pioneered the idea of operating aircraft as a pair. Rotten patrols roughly in line abreast, either pilot scanning a hemisphere of sky centred on the other aircraft. On entering combat the No 2 would swing behind the leader, who would do the fighting, while the No 1 would take the tail. A section (*Schwarm*) of four aircraft gave an even higher probability of sighting the enemy, and conveniently broke down into two fighting elements in combat. By the summer of 1916 several squadrons (*Jagdgeschwader*) were flying together. Such formations were too large to be flown line abreast, hence multiple-vee formations and diamonds came into use.

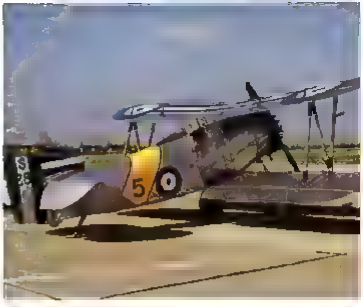
While the dogfights raged over the Continent, another important aspect of fighter operations had its beginnings in the air defence of Great Britain. Bleriot's cross-Channel flight of 25 July 1909 had given rise to fears that in the next war Britain might be vanquished by aerial invasion. Unfortunately, this threat did not materialise. Instead Britain was subjected to bombing raids by Zeppelin rigid airships and later winged aircraft, and this led to an air defence system that could operate both by day and night.

The first rigid airship with an engine had been produced by Count Zeppelin in 1875, but it was not until 2 July 1900 that the first of Count Ferdinand von Zeppelin's series, the LZ 1 (*Luftschiff Zeppelin*), left its mooring for its maiden flight, at which point in time the Count was already 72 years of age.

In the following years, his products were purchased by the Imperial German Army and Navy, he was not permitted to export, and the air transport company DELAG (Deutsche Luftschiffahrt AG), which operated with an extremely good safety record prior to the outbreak of war.

In 1914 Zeppelins were used to raid Antwerp in Belgium and on 19 January 1915 they made the first of a series of attacks on the East coast of England. Neither the RFC nor the RNAS (Royal Naval Air Service) was equipped to defend the UK, their aircraft having neither the climb performance nor the armament for the job. Nor did they have radios, blind-flying instruments, or even cockpit lighting. Nonetheless, during the night of 7 June 1915, a Morane L of the RNAS succeeded in destroying LZ 37 by dropping 20 9-kg incendiary bombs on it, while it was in flight over Ghent in Belgium.

Although the Kaiser had initially insisted that attacks should be restricted to military targets following French raids on Karlsruhe and Baden in June 1915, the Zeppelins were cleared to attack London, the first bombing taking place on 17 August. The raids were [illegible] he



winter because of bad weather and by the summer of 1916 the RFC had flarepaths and a craft equipped with luminous instruments, synchronised machine guns and effective ammunition. Pomeroy and Brook explosive bullets and Buckingham incendiaries. In August and September the Zeppelins experienced heavy losses resulting from both ground fire and interception by aircraft, and the raids petered out.

Zeppelins remained a threat to shipping in the North Sea although since early 1915 Sopwith Pups had been able to take-off from 2 [illegible]-ft (60-m) decks on the early "carriers" HMS *Campania* and *Manxman*, recovering by ditching alongside so that the pilot could be rescued. A 20-ft (6 m) take-off platform was also installed on the cruiser HMS Yarmouth, and on 21 August 1917, a Pup operating from this ship destroyed the LZ 23 which had been shadowing British vessels in this area.

As the Zeppelins withdrew from raids on the UK large aircraft took over. Gothas carried out many daylight strikes between May and August 1917 after which they switched to night raids until May 1918. The principal RFC types used for air defence were the Sopwith Camel, the SE 5a and the Bristol Fighter. On the night 28/29 January 1918, two Sopwith Camels achieved the first nocturnal 'kill' of an aircraft, shooting down a Gotha in flames. The Gothas were supplemented in 1918 by multi-engined Giants (*Riesenflugzeuge*) which made a few raids without loss.

Meanwhile in the dogfights over the trenches superiority had swung back and forth as new types of fighting scout were introduced in quick succession. The tide began to turn against the "Fokker Scourge" in the spring of 1916 with the arrival of large numbers of the single-seat D.H.2 and the two-seat FE 2b. Although both were crude pushers, they outperformed the even cruder Fokker E-series. Allied superiority was then ensured by the 1½ Strutter, the first British fighter to enter service with an interrupter gear. The lightweight, Pup and the fast-climbing, RNAS operated Triplane, all from the Sopwith stable. These aircraft had rotary engines, as did France's Nieuport 17, but the Spad 7 that entered service in September 1916 had a liquid-cooled Hispano-Suiza engine, pointing the way to the course of probable future powerplant development.

above left [illegible] Army service [illegible] B team early [illegible] and superior [illegible]

opposite [illegible] 500 [illegible] built [illegible] Hoare [illegible] K-2V

right [illegible] P-26A [illegible] Hawk [illegible]

below [illegible]

Germany regained the advantage late in 1916 by replacing the Fokker E series monoplane and Halberstadt biplane single-seaters with the Albatros D-series biplanes. These were the first single-seaters with paired synchronised guns and were powered by liquid-cooled Benz or Mercedes engines. They were followed in the summer of 1917 by the rotary-engined Fokker Dr I (Dreidecker, or triplane), in which type Werner Voss and Manfred von Richthofen achieved many "kills" and by the less successful Pfalz D III biplane powered by a liquid-cooled Mercedes engine.

However, that summer saw superiority regained by the Allies, with the twin-gun Sopwith Camel, which was difficult to fly yet achieved more "kills" than any other type, the Rolls-Royce engined Bristol Fighter, probably the finest general-purpose combat aircraft of the war, and the Hispano-engined Spad 13, arguably the best French fighter to appear during the conflict.

Germany won back control of the sky in April 1918 with the outstanding Fokker D VII, powered by a liquid-cooled Mercedes or BMW engine. France's last shot of the war was the Nieuport 28, which entered service just before the Armistice and was widely used by the Americans. Britain's Sopwith Snipe also served briefly, its 230 hp Bentley making it the ultimate in rotary-engined fighters. Its excellent manoeuvrability compensated to some extent for the slight speed advantage of the D VII, but the Snipe suffered its share of control problems and the Martinsyde F 4 Buzzard (which narrowly missed active service) was certainly technically more advanced.

To summarise, fighter performance developments during the four years of war, rotary engines had increased from around 60 hp to the 230 hp of the Snipe, while liquid-cooled engines had gone to 180 hp in the D VII, 275 hp in the Bristol Fighter and 300 hp in the Buzzard. Level speeds had correspondingly risen from 70 mph (112 km/hr) for the Gunbus to 122 mph (195 km/hr) for the Nieuport 28 and 144 mph (230 km/hr) for the Buzzard. Service ceilings had gone up from around 13,000 ft (3,960 m) to 21,800 ft (6,650 m) for the Spad 13 and 23,950 ft (7,300 m) for the Buzzard.

At the end of the war, most aircraft still had wooden structures with fabric covering, although the Albatros, Roland and Pfalz series had wooden monocoque fuselages.

The principal antag[illegible] Battle of Britain were the cutting-edge fighters [illegible] B[illegible] and the [illegible] Hurricane, a [illegible] **Insel** [illegible] Fighters flying over the Western Desert [illegible] flying in formation with two Spitfire [illegible] **head of page** [illegible] Bf 109s or Zs 26 in the Mediterranean Theatre. **Immediately above** An early production Curtiss P-40 [illegible] to Wright Field in 1940. Lacking self-sealing fuel tanks, protective armour and adequate armament, this fighter was shot [illegible] practically everywhere [illegible] standards and the introduction of these items was to have a decisive effect [illegible] performance. The Grumman F4F Wildcat **right**, [illegible] was inferior [illegible] of its day and [illegible] that [illegible] to [illegible] the Royal Navy. By [illegible] it was [illegible] known as the Martlet, received no fewer than 320 Wildcats.

The shortage of good quality spruce had raised interest in the use of metal structures, especially in Germany, where Junkers flew the J 1, the world's first all-metal, fully cantilevered monoplane, in 1915. Junkers continued with the concept of a corrugated steel skin on top of a welded-steel load-carrying framework until the J 7 of 1917 finally succeeded in winning a production order. Fitted with two forward-firing Spandau machine guns, it was known as the D.I, but only 41 had been delivered at the end of the war. The Rohrbach company also tried metal construction, using smooth skins, which gave less drag but lacked stiffness.

The standard air-to-air armament was still a lightweight version of an army weapon, although other types of weapon were used experimentally. The Le Prieur rocket was tested on various aircraft (eg, Sopwith Pup) as a means to attack balloons and Zeppelins, but had a range of only 300 ft (90 m). A 37-mm Hotchkiss cannon was fitted between the cylinder blocks of the Spad 12 Ca 1, and the Vickers one-pounder pom-pom naval gun was used on the FE 2b to attack Zeppelins. But the slow fire rate of heavy-calibre guns was generally felt to offset the benefit of the larger projectile.

Several types of aircraft were fitted with armour plate (eg. Sopwith Salamander) as fighters were used later in the war for trench strafing.

Other aircraft features that became important later in the story of fighter development had their origins in this period. The S.E.4 experimental biplane of 1914 had gaunter changing flaps and a celluloid cockpit canopy. The Sopwith 1½-Strutter of 1916 had airbrakes and a variable incidence tailplane. The same year saw a supercharger tested in an aircraft and 1918 witnessed the use of a two-pitch propeller. A crude form of semi-retractable undercarriage had appeared even before the war, on the German Eugen Wienczierz monoplane of 1911.

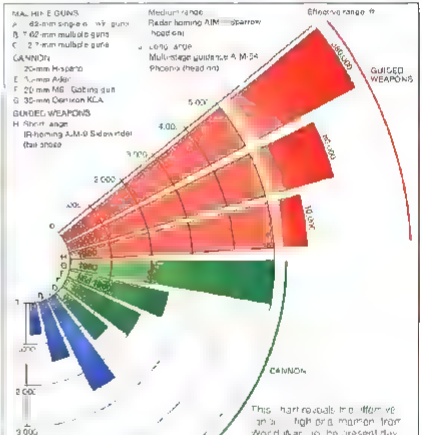
Radios were used on some two-seaters, which trailed a 120-ft (37-m) length of copper wire with a weighted end. They communicated by wireless telegraphy (ie. Morse code) over a range of 10 miles (16 km). Oxygen equipment and electrically-heated clothing were developed to facilitate high altitude flying, but were not used operationally.

The parachute is said to date back to 1797, but the first human demonstration is reported to have occurred in 1908 when US showman Leo Stevens jumped from a balloon. In October 1912 a man jumped from a Wright biplane using a Stevens "Life Pack". By 1918 parachutes made by Pauling and Heinecke were in limited use in German aircraft, and the Calthrop Guardian Angel was available on the British side and selected for the Snipe, but not used.

Between Wars

With the Armistice of November 1918, Germany was temporarily out of the running and the US was intent on never again becoming involved in war, hence the lead in fighter development was left to Britain and France. Italy had been successful with bombers, but it was to be some years before she was to produce a ready competitive fighter.

Britain's Royal Air Force, formed on 1 April 1918 by merging the RFC and the RNAS, was initially restricted in improving its equipment by a rolling Ten-Year Rule, which foresaw no threat in that period and hence recognised no call to spend money on new equipment. The Snipe rather than the Bazzard was chosen to be the RAF's standard



This chart reveals the different ranges of high performance from World War II to the present day. It is not absolute maximum values. Although the figures are accurate representations of the precise effective ranges depending on so many variable factors this the numbers quoted are no more than illustrative of the trend.

[illegible] **top p20** and the P-[illegible] **middle p20** [illegible] **bottom p20** was even especially on the [illegible] WWII [illegible] **top left** was [illegible] first of the Hawk B-A series fighters produced in quantity for the USAAF as performance being [illegible] pedestrian but the [illegible] **middle left** represented a maximum [illegible] standard fighter capability. The Hawk shown KP [illegible] **bottom left** was the most effectively [illegible] WWII [illegible] New fighter [illegible] comparable with the best [illegible]

fighter, and as such it remained in service until 1925. The 1920s produced a rash of new British biplane fighters, all fitted with fixed radial engines: the 325 hp Armstrong Whitworth Siskin III, the 400 hp Gloster Grebe and 425 hp Gloster Gamecock and Siskin IIIA, and the 490 hp Bristol Bulldog. For its generation the Bulldog was a fine aircraft, with a maximum speed of 174 mph (278 km/hr) and a ceiling of 27,000 ft (8,230 m). It entered service in 1929 and was the RAF's most widely-used fighter until 1936. The most significant aircraft on the naval side was the 400 hp Fairey Flycatcher, which served with the Fleet Air Arm from all the RN carriers in the period 1923-34.

France's equivalent of the Snipe was the much faster Nieuport 29 biplane, but thereafter her fighters lost ground to the British: the all-metal Wibault 72 and the Loire-Gourdou-Leseurre 32 (both parasol-wing aircraft) and the Nieuport-Delage 62, 622, 629 sesquiplane series being notably slower than their RAF contemporaries. Dewoitine had meanwhile been developing a line of parasol-wing fighters of metal construction, but with fabric-covered wings. These aircraft did not initially win French orders, but they were used abroad, notably in Switzerland and Italy. The series culminated in the Swiss-built D 27 of 1930 and the French-built D 371 of 1934.

The 1920s had not been an outstanding decade in terms of operational fighters, but significant developments had been initiated. In 1920, Short Bros exhibited the Silver Streak biplane with a monocoque duralumin fuselage. The same year saw the first fully-retractable main undercarriage members fitted to the Dayton-Wright high-wing racer, the mainwheels being housed by the fuselage. In 1922, the Verville-Sperry racer had the main gear retracting into the wings. Two years later, in 1924, the British Air Ministry declared that all primary structure in its future aircraft would be metal, but did not rule against fabric covering. Significantly, in 1925, the Schneider Trophy race was won for the last time by a biplane: the Curtiss R3C-2 averaging 232.5 mph (372 km/hr). In 1928-29, the first rocket-powered glider flights were made in Germany.

During the 1930s, biplanes gave way to monoplanes, and stressed skin structures came into general use, as did enclosed cockpits, radio telephony (as voice transmissions

The P-38 Lightning (**above**) was the only twin-engined single-seat fighter in sole large-scale service in WWII and the de Havilland Mosquito (**left**), although conceived primarily as a bomber, found its true metier as a two-seat fighter, a class in which it was to become the most versatile. The Thunderbolt (illustrated is the P-47B) (**top right**) was by far the largest and heaviest single-engined fighter ever built, when it first entered USAAF service, dwarfing the North American Mustang. The P-51 D version of which is illustrated, had been developed originally to meet an Allied requirement that a fighter be designed as long as the best all-round single-seat fighter in Germany, in WW II, the Messerschmitt Bf 109. Like all single-engined P-51s, it lacked the necessary altitude capability for the air war in Europe. But, in conjunction with the Merlin engine, it was transformed and its range capability for escort missions was second to none. The Northrop Black Widow, seen here in pilot P-61A production form (**right**), was the first fighter designed primarily for the night interception role from the outset.

retractable undercarriages, high octane fuels, and variable-pitch propellers. Research into gas turbines for jet propulsion was pursued actively in Germany, Britain and elsewhere.

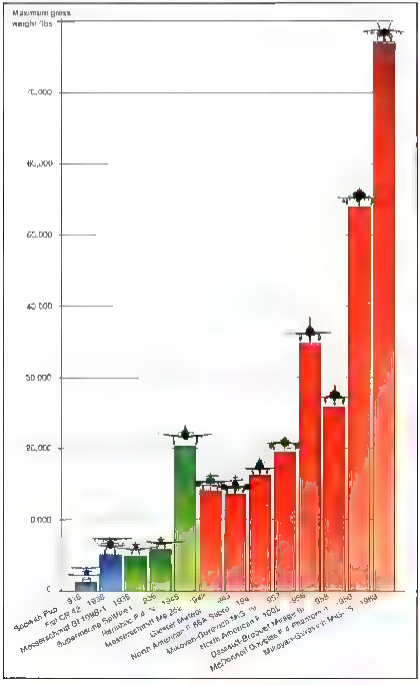
It was at this time that the United States was first to take the lead in fighter development, albeit only briefly. The Curtiss series of liquid-cooled engines developed for racers in the 1920s had led to a series of biplane fighters, but none of these had been produced in large numbers. Curtiss had begun the Hawk biplane series with the P-1 pursuit aircraft for the USAAC and the F6C for the USN, competing with the P-6E, the Army's last biplane fighter, which entered service in 1932. Boeing used the Curtiss engines in the Army's PW-9 and the Navy's FB-1 series, but switched to the P&W Wasp radial for the Army P-12 and Navy F4B. The US Navy persisted longer with biplanes than the Army or Navy. In the mid-1930s the Grumman F2F series, with a retractable, retracting into the fuselage. However, the aircraft that put the US briefly in the vanguard of fighter development was the Boeing P-26 all-metal monoplane. When it entered service with the Army at the end of 1933 it was arguably,

the most advanced fighter in the world despite such anachronistic features as bracing wires and fixed, spatted undercarriage (see photograph on page 17)

In Britain, some highly streamlined biplanes were built around liquid-cooled Rolls Royce engines, notably the Hawker Fury and the same company's Demon turret fighter. However, for the RAF's final biplanes, radial engines were to be used. The Gloster Gauntlet of 1935 was used in the first radar-directed interception two years later and its descendant the Gladiator of 1937, made some concessions to modernity in having an enclosed cockpit, a reflector gunsight and a quartet of Colt Browning machine guns which had replaced the unreliable Vickers in aircraft use. The Gladiator had a maximum speed of 253 mph (405 km/hr), which was marginally better than the 240 mph (384 km/hr) of the Curtiss Hawk III, but not as good as the 264 mph (422 km/hr) of the Grumman F3F-3, the US Navy's last biplane fighter.

The rebirth of the German Air Force was revealed officially in March 1935, but deliveries of the Heinkel He 51 biplane fighter had started late in 1933. Although historically important as the first of Germany's new single-seat fighters which saw service in the Spanish Civil War from November 1936, its performance was unremarkable. Some of the finest biplane fighters were by now produced in Italy, notably the Fiat CR.32 (which was also used in Spain) and from the same stable, the CR.42 Falco, the last and the fastest of the series, with a maximum speed of 267 mph (427 km/hr) equalling the contemporary Polikarpov I-153 which featured undercarriage retraction. However, the biplane fighter is held by some experts to have reached its peak with Czechoslovakia's Avia B.534 which came second to the Messerschmitt Bf 109 in the Zurich Air Meeting of 1937.

The Boeing P-26, which had first flown on 30 March, 1932 and had entered service late in 1933, was soon to be overtaken by other fixed-gear monoplanes from Europe and Japan. Poland's high-wing PZL P11 had flown in 1931 and was marginally faster, but only entered service in 1934. It still formed the backbone of Poland's air force when war broke out in September 1939, by which time it was completely outclassed by Germany's fighters. In France, Dewoitine finally abandoned the parasol wing in favour of a



above top

formidable

The diagram **left** illustrates the maximum gross weight of Bundesbound jets during flight, beginning with the piston-engined biplanes and monoplanes of the early years and ending with the jet fighters of the Vietnam era. The McDonnell Douglas F-4 Phantom II, last of the Western aircraft to be used in the Vietnam War, played a very high standard.

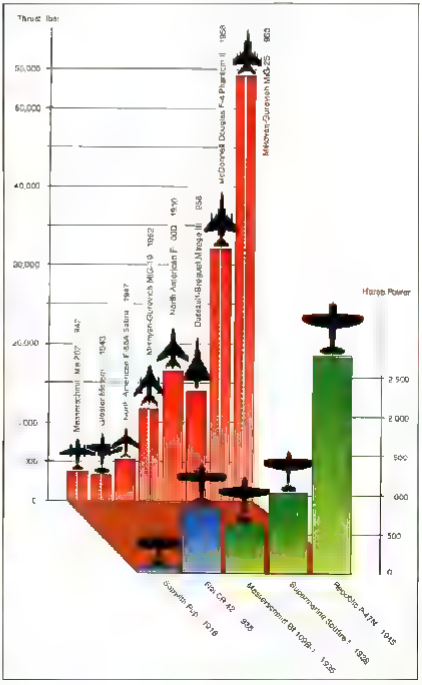
low setting for the wing of the D 500 series, which had a maiden flight on 19 June 1932 and entered service late in 1934. The D 501 differed in having a modified carburettor mounted between the cylinder blocks and firing through the propeller boss, and the 860 hp D 510 reached 250 mph (400 km/hr). However, an even faster fixed-gear aircraft was the Japanese Imperial Navy's Mitsubishi A5M, which was employed against China in 1937, but has been virtually withdrawn from the first-line inventory by the time of the Pacific War, which started with the attack on Pearl Harbor. Its Army contemporary was the Nakajima Ki-27, which did see quite extensive wartime use and which had a maximum speed of 268 mph (458 km/hr), making it a fine leader in this class with the Fokker D XXI.

The aircraft which opposed the A5M over China in 1937 was conceptually more advanced, but an older aircraft of inferior performance. This was the Soviet Union's Polikarpov I-16, which had first flown at the end of 1933 and was the world's first single-seat, low-wing monoplane fighter with a retractable undercarriage to enter service. Later models did reasonably well against the Bf 109E in Spain, and in its ultimate form it reached a speed of 328 mph (522 km/hr).

Other retractable-gear monoplane fighters followed the I-16 in rapid succession. The year 1935 saw the first flight of the Curtiss P-36, Messerschmitt Bf 109, Morane-Saulnier MS 406, Seversky P-35 and the Hawker Hurricane, to be followed in 1936 by the Supermarine Spitfire, Messerschmitt Bf 110 and the Junkers 88, the last-mentioned being destined to become one of WWII's finest multi-role combat aircraft. In 1937 more single-seaters appeared in the form of the Fiat G.50, Bloch 150, Grumman F4F Wildcat (the first American naval fighter able to compete with its Japanese contemporaries on reasonably even terms) and the Macchi C 200. These were followed, in 1938, by the Curtiss P-40 prototype, the basis for the Tomahawk and Kittyhawk (alias Warhawk) and the Dewoitine D 520, the most advanced French fighter of the period. Finally, in the last few months before the war, appearances were made by the Lockheed P-38 Lightning twin-boom fighter, the Japanese Army's Nakajima Ki 43 and its Navy rival, the Mitsubishi A6M Zero, Germany's outstanding Focke-Wulf Fw 190 and Britain's Bristol Beaufighter. All were to prove important fighters in the conflict.

Contemporary of the Messerschmitt Me 262 was the Gloster Meteor, **immediately above**, a twin-jet Allied World War II service, the F Mk 4 version illustrated entering RAF service from 1948.

The diagram **right** is indicative of the increase in horse power (piston engines-from propellers) and thrust (jets-back pressure) that has occurred over the past 65 years. The MiG 19 and F-104 were the principal fighters introduced after 1960.



that began in September, but from a technology viewpoint perhaps the most important event of 1939 was the first flight of the turbojet-propelled Heinkel He 178 on 27 August. Crude as it was, the He 178 served notice that the piston-engined fighter would not survive another decade.

World War Two

The second four decades of aviation development will naturally be better known to the average reader, and this later period is therefore summarised only briefly below.

France's MS.406 was numerically the country's most important fighter, but was completely outclassed by the Bf 109. The Dewoitine D.520 was more comparable to the German aircraft, but was not available in sufficient numbers to affect the outcome of the battle over France. Italy had emphasised biplanes, rather than monoplanes, and lacked sufficiently powerful engines to exploit its designers' talents. The Fiat G.50 and Macchi C.200 were inferior in performance as distinct from agility to their British contemporaries, and were relegated to escort and fighter-bomber roles. Later, the availability of the Daimler-Benz DB 601 engine enabled Italian fighters to take a major step forward, with the Macchi C.202 and Reggiane Re.2001 which were reasonably successful. The even more powerful DB 605 powered the Fiat G.55, the Macchi C.205V and the Reggiane Re.2005 which were equal to any other fighters of the period, but arrived too late to play really significant roles.

The 'Battle of Britain' was won by sheer numbers of Hurricanes, the dogfight qualities of the Spitfire and the force-multiplier effect of ground-controlled interceptions, making the first significant use of radar. It can be argued that the results would have been even more dramatic if the British 0.303-inch (7.7-mm) machine gun had been replaced by that of 0.50-inch (12.7 mm) used by the Americans, Russians and Germans. However, Britain instead made the leap to the 20-mm Hispano cannon, which became the RAF's standard fighter armament until the 30-mm Aden was introduced by the Hunter in the mid-1950s.

The Spitfire was superseded by the Hawker Typhoon and Tempest at low levels, but remained supreme at high altitudes throughout the war, production finally terminating in

The supremely graceful Hawker Sea Hawk (**above**), seen in German Marineflieger markings, Mk 100 entered Royal Navy service in the early fifties and was still serving with the Indian Navy at the end of 1998. The North American Sabre, the F-86F version being illustrated (**left**), represented an outstanding technological milestone in fighter performance and was the first swept-wing fighter capable of high speed, high manoeuvrability, 'kills' opponent over Korea. The MiG-15 was somewhat less sophisticated, but the Soviet fighter's shortcomings were largely overcome by the progressive development of the basic design. The Mig [illegible] (**top right**) Seen in its initial pressed-A version in Cuban service, the Soviet MiG-17 fighter was a [illegible] design of the MiG-15, the entire fuselage and the fighter forward of the engine plenum chamber rear frame was retained. The only fighter of Canadian design to achieve quantity production, the Avro Canada CF-105 Canuck (**middle right**) all-weather fighter was optimised for the rigorous Canadian operating conditions. The Hawker Hunter (**right**), was considered by many the classic fighter of the fifties and remains in service with several air forces to this day.

1947. The Hurricane was quickly relegated to ground attack, convoy protection and service in secondary theatres. The Typhoon excelled mainly in ground attack, but the Tempest could match the best of German piston-engined fighters at low and medium levels.

The radar-equipped Beaufighter played an important part in stemming the night time Blitz, and the aircraft was later used as a long-range fighter, especially in anti-shipping strikes. However, it was the de Havilland Mosquito that became Britain's most outstanding multi-role fighter, despite what many viewed as the retrogressive use of a wooden structure. In naval operations, British fighters failed to excel although the two-seat Fairey Firefly did play a useful role later in the war and in the Korean conflict.

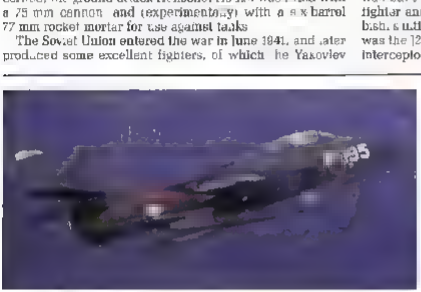
The first British turbojet-powered aircraft – the Gloster E.28/39 – made its maiden flight on 15 May 1941. Based on the Gloster Meteor, early versions of which were much slower than the contemporary Messerschmitt Me 262, but were nonetheless effective in intercepting V-1s, the forerunners of the cruise missile. The de Havilland Vampire missed the war completely.

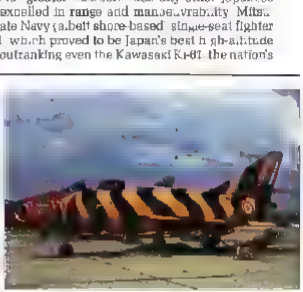
Germany's Messerschmitt Bf 109 was produced in greater numbers than any other fighter, but reached its peak of development early in the war with the Bf 109F after which it became overloaded and lost its manoeuvrability. The Bf 110 failed as an escort fighter, but performed usefully later as a radar-equipped night fighter, alongside the multi-role Ju 88. The Fw 190 and its Ta 152 descendant represented the peaks of German piston-engined fighter evolution.

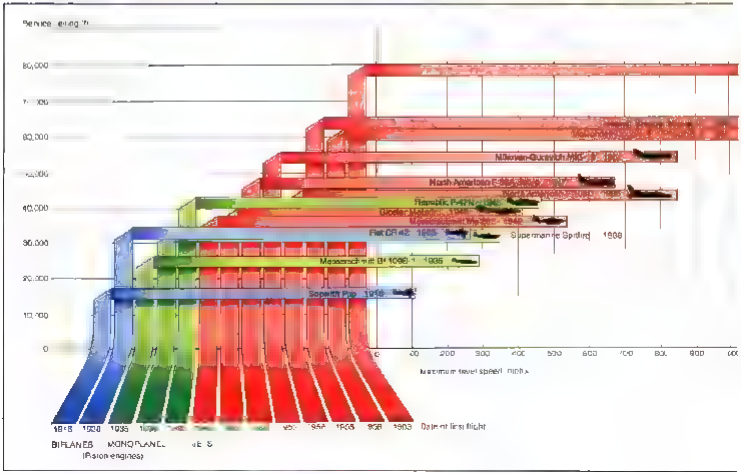
Germany was the only country to make significant use of jet fighters during the war, with the turbojet-powered Me 262 and rocket-powered Me 163, both swept-wing aircraft, although, in the case of the former, sweepback had been adopted purely for CG reasons. The Germans also led in the development of air-to-air guided weapons, and ended the war with a 30-mm cannon that formed the basis for the post-WW II Aden and DEFA. Insofar as larger calibres were concerned, the ground-attack Henschel Hs 129 was fitted with a 75 mm cannon, and (experimentally) with a six-barrel 77 mm rocket mortar for use against tanks.

The Soviet Union entered the war in June 1941, and later produced some excellent fighters, of which the Yakovlev series is generally agreed to have been the best, if rudimentarily equipped by Western standards of the day. Of the family, the Yak-9 and the lightweight Yak-3 were outstanding. The radial-engined Lavochkin La-5 and La-7 were able to compete successfully with their German contemporaries, and the Mikoyan-Gurevich MiG-3 achieved some measure of distinction during the early part of the war for its speed and altitude capabilities. Soviet wartime fighters introduced cannon of 23 mm and 37 mm calibres. The former calibre proved exceptionally successful and is still in use today, whereas Soviet 37 mm aerial cannon were too slow-firing and did not survive the early jet fighters.

Japan and the United States entered the war on 7 December 1941 with the former's attack on Pearl Harbor. The Japanese Navy's Mitsubishi A5M had already been largely superseded by the retractable-gear A6M Zero-sen, which was still in far greater numbers than any other Japanese fighter and excelled in range and manoeuvrability. Mitsubishi's ultimate Navy (albeit shore-based) single-seat fighter was the J2M, which proved to be Japan's best high-altitude interceptor outranking even the Kawasaki Ki-61, the nation's







only fighter with an in-line engine (a licensed DB 601).

Early in the war, the Army's Nakajima Ki-27 began to give place to the Ki-43, the service's most widely used fighter. The same company developed the Ki-44 for home defence. Japan's most advanced fighters, which could hold their own with the best American types, were arguably the Army's Nakajima Ki-84 and the Navy's Kawanishi *Shiden*.

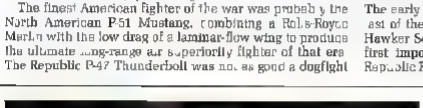
The United States' earlier fighters of WWII were somewhat pedestrian in capability, although some performed usefully, eg the Curtiss P-40 as a sturdy fighter-bomber and the Bell P-39 Airacobra as a Lease-Lend aircraft for the Soviet Union. Of later types, the Northrop P-61 Black Widow was an effective night fighter and the Lockheed P-38 excelled in the long-range operations of the Pacific theatre once tactics had been developed enabling it to mix it with the more manoeuvrable Japanese fighters.

The finest American fighter of the war was probably the North American P-51 Mustang, combining a Rolls-Royce Merlin with the low drag of a laminar-flow wing to produce the ultimate long-range air superiority fighter of that era. The Republic P-47 Thunderbolt was not as good a dogfight aircraft, but its greater weight provided operational flexibility and the radial engine with which it was equipped reduced vulnerability to enemy fire.

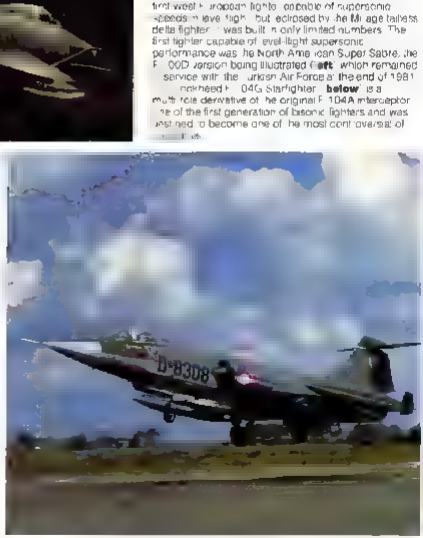
In naval operations, the Grumman F6F Hellcat was virtually the equivalent of the P-51, but it was surpassed in certain performance aspects by the Vought F4U Corsair, which, if leaving much to be desired in respect of deck characteristics, continued in service through the Korean War. The USA made a slow start in gas turbine engine development, but both the Bell P-59 Aracomet and Lockheed P-80 Shooting Star flew in limited numbers prior to the end of the war in August 1945, although neither saw operational service in that conflict.

Post-War Years

The early post-war period saw the entry into service of the last of the great piston-engined naval fighters, namely the Hawker Sea Fury and the Grumman F8F Bearcat, and the first important straight-wing jets, as instanced by the Republic F-84 Thunderjet and the Hawker Sea Hawk. These



The Republic F-84F Thunderstreak, **far left**, derived from the straight-wing F-84G Thunderjet, was optimised for the fighter-bomber mission and served with several NATO air forces until the early seventies. The Dassault Super Mystère B2 (**middle left**) was the first western production fighter capable of supersonic speeds in level flight, but eclipsed by the Mirage III delta fighter. It was built in only limited numbers. The first fighter capable of level-flight supersonic performance was the North American Super Sabre, the F-100D version being illustrated (**left**), which remained service with the Turkish Air Force at the end of 1981. The Lockheed F-104G Starfighter (**below**) is a multi-role derivative of the original F-104A interceptor, one of the first generation of supersonic fighters and was destined to become one of the most controversial of all time.



The graph (**left**) shows the progression of attainable maximum speed and service ceiling of fighter aircraft. The Soviet-built MiG-25 is unique in that it is the world's only interceptor capable of approaching speeds near Mach 3. The Mirage and the F-4 Phantom are representatives of the upper speed limit for attainable altitudes. It should be noted that an aircraft does not necessarily achieve its maximum speed and maximum altitude at the same time.

years also saw the advent of a new generation of swept wing jet fighters.

The North American F-86 Sabre, which first flew on 1 October 1947, was one of the truly great fighters combining a major advance in performance with good handling qualities and successful operation in combat. Its development also marked the somewhat late transition of the USAF from the 0.50-inch (12.7 mm) machine gun to the 20-mm cannon introduced on the F-86H which also had a nuclear delivery capability. The F-86D limited all-weather fighter had nose radar, an afterburning engine and a retractable pack of 2.75-inch (70-mm) unguided rockets. Later Sabres could use the AIM-9 Sidewinder air-to-air missile but it is the six-gun F-86A, E and F variants that fought over Korea for which the type will best be remembered.

The MiG-15, which first flew on 30 December 1947, was an equally bold design but was noteworthy mainly for squeezing a high subsonic performance from a centrifugal-flow engine, a pirated copy of the Rolls-Royce Nene foolishly sold to the Soviet Union by Britain's government of the day. The aircraft had a very good ceiling but was inferior to the

F-86 in a number of respects having been evolved primarily as an anti-bomber weapon rather than for fighter-versus-fighter combat and it was soon superseded by the MiG-17, a large-scale rehash, some variants of which had an afterburner. The MiG-17 was a major improvement and remains in service in the early 'eighties with some smaller air forces as a light fighter-bomber, roughly equivalent to Britain's Hawker Hunter. It is noteworthy that the first European swept-wing fighter was the Saab J 29 which first flew on 1 September 1948.

Some aircraft capable of level supersonic flight were already under development during the Korean War. These included the North American F-100 Super Sabre which became an outstanding fighter-bomber and the MiG-19, which is still widely used, and has been developed in China as a tactical strike aircraft. However, Korea gave rise to a demand for low cost air superiority aircraft with genuine Mach 2 performance, which in turn resulted in three outstanding fighters, the MiG-21, the Lockheed F-104 and the Dassault Mirage III. The Saab J35 Draken was in the same class but failed to achieve fame due to Swedish export restrictions. Another important dogfight aircraft was the Vought F-8 Crusader which proved its value in Vietnam.

In the field of interceptors, the Convair F 102 and F 106 were early examples of Area Ruled fuselages and internal weapon bays, while the BAC Lightning was more of a technical curiosity, with a high wing sweep and vertically-stacked engines. The massive Tupolev Tu-28P illustrated the size of aircraft required to provide area defence over the Soviet Union. However, the most important interceptor to originate in the 1950s was the McDonnell Douglas F-4 Phantom II, with an armament of four AIM-9 Sidewinder and four AIM-7 Sparrow missiles. Designed as a US Navy interceptor, this incredibly flexible aircraft was used later in Vietnam and the Middle East both as a fighter-bomber and an air superiority fighter.

The outstanding strike fighter of the period was the Republic F-105 Thunderchief with an internal bay for nuclear weapons and highly sophisticated intakes. It performed well in Vietnam and continues in service today. At the opposite end of the weight spectrum the lightweight Northrop F-5 combined the aerodynamic advantages of Area

The remarkable variety of configuration adopted during the late fifties through the sixties for supersonic fighters is graphically illustrated on these pages. The Republic F-105 Thunderchief (**top p30**) was designed from the outset for the fighter-bomber role and has a wing swept 45 deg at quarter-chord and mated with an hourglass-shaped fuselage. The Saab J35 Draken (**middle p30**), intended primarily for the interceptor mission, introduced a double-delta wing planform that has remained unique to this day. The Mikoyan-Gurevich MiG-21 (**bottom p30**) originally conceived as a lightweight diurnal air superiority fighter and progressively developed as a limited all-weather dual role fighter adopted the tailless-delta arrangement which endowed it with certain advantages over its Western contemporaries, whereas the Dassault Mirage (**above left**) opted for the tailless delta arrangement with its attendant approach speed and landing performance penalties. The BAC Lightning (**above top**) employed the maximum feasible sweepback of 60 deg, a wing that was referred to as a notched delta and mated with a deep fuselage in which two turbojets were vertically staggered and the McDonnell Douglas F-4 Phantom (**above**), the most significant and successful jet fighter of the series, adopted a more moderate 45 deg quarter-chord sweepback enhancing directional stability with upward-canted outer panels. The Northrop F-5E Tiger II (**left**) designed primarily as a low-cost air-to-air fighter and widely exported in the seventies, reverted to an unswept wing configuration, while the Saab Viggen, the JA 37 version of which is illustrated (**below left**) is a unique close-coupled canard delta, the foreplane contributing a substantial proportion of lift. The configuration adopted for the Viggen was being utilised by several fighter projects being offered in the early

Rule with the weight saving of small afterburning engines and highly accurate IR homing missiles it became a supersonic fighter that even small nations could afford and provided a sound basis for a long line of developments which are likely to reach their apex with the F-5G of 1982.

The 1960s were characterised by an explosion in fighter development costs in the West, hence only the most dramatic advances were funded. The start of the decade saw the first hovers and transitions by the Hawker P.1127, the world's first practical high-performance V/STOL aircraft. The P.1154 proposed as a supersonic development was cancelled in 1965, but the subsonic Harrier entered service with the RAF in 1969 and with the US Marine Corps as the AV-8A in 1971, progressive development continuing with the AV-8B for both the USMC and RAF in the mid-eighties. The radar-equipped Sea Harrier was issued to the RN in 1979, three years after the Soviet VTOL Yak-36 was first seen.

The other dramatic development of the early 1960s was the Lockheed YF-12A, the first interceptor capable of Mach 3. This was abandoned, but the series continued in the form of the SR-71 reconnaissance aircraft. The Soviet Union

adopted a brute force approach to the same problem, producing the aerodynamically less refined MiG-25, which is used both as an interceptor and for reconnaissance.

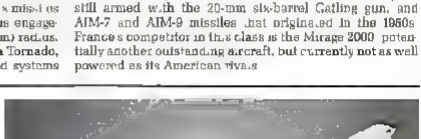
The Lockheed approach of optimising the airframe for supersonic cruise had virtually ignored airfield performance. The variable-sweep wing concept was developed in the 1960s to make a good supersonic shape compatible with normal airfields. The first practical application was the General Dynamics F-111 strike fighter but a similar wing geometry was later used in the MiG-23 and the more recent Su-24, which is directly comparable to the F-111, while a form of semi-variable-geometry has been utilized by the Su-17 series which saw birth as a form of an incremental design development exercise based on the fixed-wing Su-7.

In pure fighter terms the most remarkable application of variable geometry is perhaps the Grumman F-14 Tomcat naval interceptor with long range AIM-54 Phoenix missiles and AWG-9 radar, making possible simultaneous engagements of multiple targets at over 100 miles (160 km) radius. One of the most recent VG fighters is the Panavia Tornado, effectively a miniature F-111 with more advanced systems and multi-role capability. Sweden's equivalent of Tornado is the Saab Viggen, which used instead a canard configuration.

One outcome of the Vietnam War has been a demand for long-range, highly manoeuvrable air superiority fighters, based on a new generation of engines and new armament and control concepts. The first result of this demand was the McDonnell Douglas F-15 Eagle, using two P&W F100 engines. Requirements for a lightweight, low-cost complement for the F-15 led to the General Dynamics F-16 Fighting Falcon with a single F100 engine, and featuring a sidestick controller, relaxed static stability and fly-by-wire controls.

Its naval equivalent is the McDonnell Douglas/Northrop F-18 Hornet with two GE F404 engines and a unique capability to operate to high angles of attack and sideslip. These three US fighters represent tremendous advances in manoeuvrability, acceleration and climb rate, but they are still armed with the 20-mm six-barrel Gatling gun, and AIM-7 and AIM-9 missiles that originated in the 1950s. France's competitor in this class is the Mirage 2000, potentially another outstanding aircraft, but currently not as well powered as its American rivals.

variable-wing geometry, while introducing a measure of complexity, offers certain advantages over a fixed-geometry wing, where particular weaknesses in low-speed and endurance requirements are combined with demands for high speed capability. Two great names of production fighter design, the wing-pivot F-14 Tomcat on the port bow and the variable-geometry Panavia Tornado **inset**, the McDonnell Douglas F-15 Eagle **left** employs an extremely simple and comparatively lightly armed wing in order to achieve outstanding manoeuvrability and the comparable Dassault Breguet Super Mirage 4000 **right** reverts to the tailless delta configuration but overcomes the principal shortcomings previously inherent in such by means of advanced control technology. The McDonnell Douglas AV-8B (**below**) is a new aircraft as a progressive development of the BAe Harrier being developed for the RAF and the USMC and is expected to enter service with those forces in the latter half of the decade.



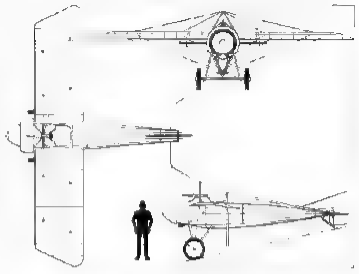
Morane-Saulnier Type N (May 1914)

Comparatively few of aviation's early practitioners foresaw a combat role for single-seat aircraft while accepting their potential value as 'scouts' for the Army. The concept of the fighter intended primarily for aerial combat was, in the event, to evolve during the first year of World War I; the first dedicated single-seat fighters were to result from fortuity rather than original intent. Among what were effectively the earliest single-seat fighters were the Morane-Saulnier Type N and its German contemporary the Fokker E I, neither conceived with a military application in mind and both to prove significant for their contributions to the evolution of practical fighter armament.

Both French and German types were flown in May 1914, the former being demonstrated in the following month at Aspern, Vienna. The Type N followed a series of aerodynamically clean monoplanes created by Léon Morane and Raymond Saulnier, emulating its predecessors in the use of wing warping for lateral control but offering a noteworthy advance in refinement. Its fabric-skinned fuselage was faired out fully to a circular cross section, the aerodynamic entry to which was afforded by an enormous aluminium propeller spinner (much in evidence in the cutaway drawing below; see key number 8).

The performance of the Type N, which was to be referred to widely, albeit inaccurately, as the Morane Monocoque aroused some interest on the part of the *Aviation militaire* and a military production version was defined in June 1915. At this time, the Type N was fitted with a propeller equipped with heavy steel deflector plates intended to deflect bullets striking the propeller from the forward firing machine gun. This rudimentary and somewhat alarming means of firing through the propeller arc was adopted for the score or so Type N monoplanes accepted by the *Aviation militaire* and the 24 similar aircraft that were to be delivered to the Royal Flying Corps from March 1916.

Some of the RFC Type N monoplanes, which were to become unofficially known as Bullets, were equipped with a wing of modified section which produced a modest performance improvement but did little to alleviate the execrable handling characteristics. The Type N was unusually difficult to fly owing to the uneasy combination of heavy lateral control dubiously provided by wing warping and extreme sensitivity of the balanced elevators. Withdrawn from French operational service before the end of 1915, the Type N remained with the RFC throughout 1916, seeing much action in the grim summer of that year.



SPECIFICATION: Type N

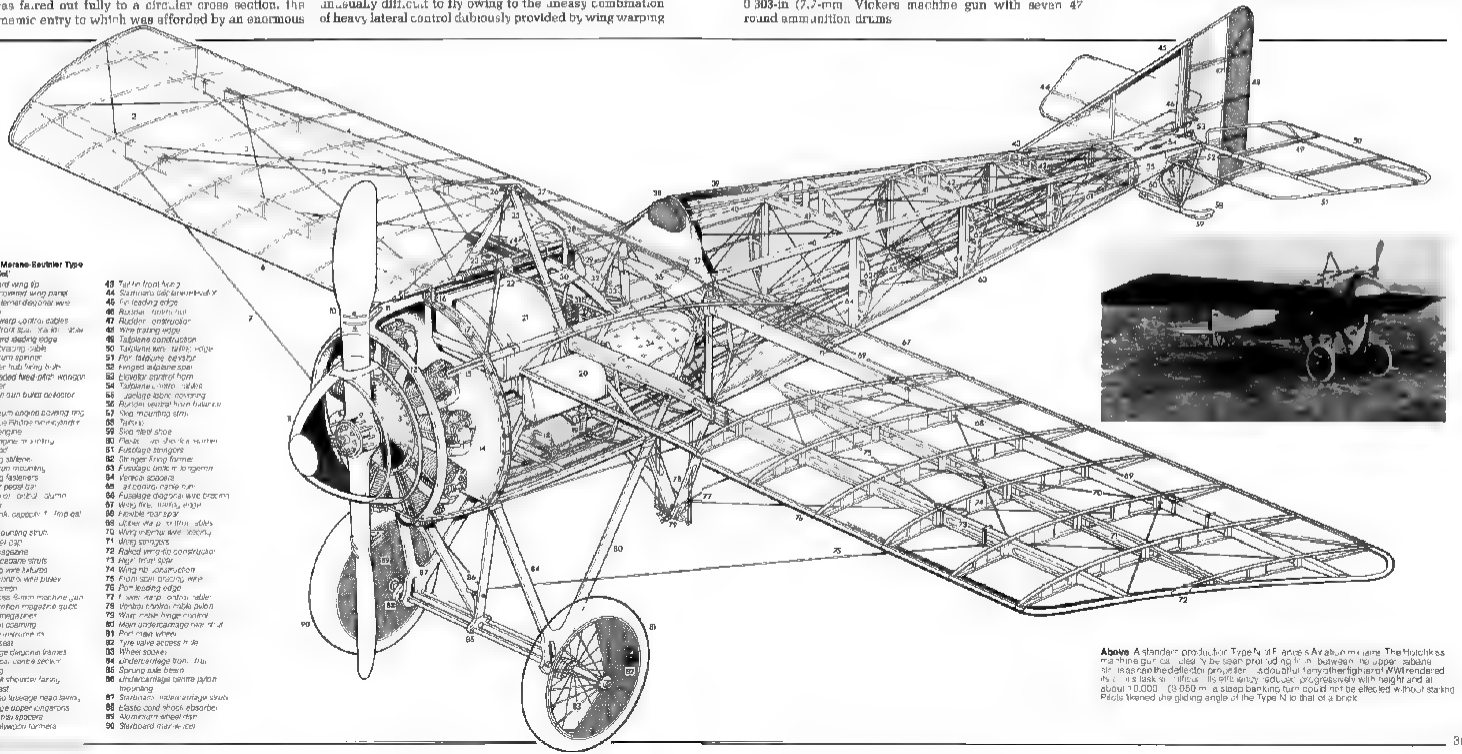
Power Plant: One Le Rhône 9C nine-cylinder rotary air-cooled engine rated at 80 hp at 1,200 rpm for take-off. Two-bladed wooden fixed-pitch propeller. Internal fuel capacity, 11 Imp gal (50 l).

Performance: Max speed (original wing), 90 mph (144 km/h) at sea level (revised wing), 94.5 mph (152 km/h) at sea level; time to 3,280 ft (1000 m), 4.0 min, to 6,560 ft (2,000 m) 10.0 min; endurance, 1.5 hrs.

Weights: Loaded, 976 lb (443 kg).

Dimensions: Span, 26 ft 8⅝ in (8.15 m); length, 19 ft 1½ in (5.83 m); height, 7 ft 4½ in (2.25 m); wing area, 118.4 sq ft (11.00 m²).

Armament: One 8-mm Hotchkiss machine gun or one 0.303-in (7.7-mm) Vickers machine gun with seven 47-round ammunition drums.



Key to Morane-Saulnier Type N "Bullet"

1 Starboard wing tip
2 Fabric-covered wing panel
3 Wing internal diagonal wire bracing
4 Upper warp control cables
5 Upper front spar
6 Starboard leading edge
7 Lower bracing cable
8 Aluminium spinner
9 Propeller hub fairing boss
10 Two-bladed fixed-pitch wooden propeller
11 Machine gun bullet deflector plate
12 Aluminium engine cowling ring
13 Rotary engine
14 Stub engine mounting bulkhead
15 Cowling latches
16 Front gun mounting
17 Cowling fasteners
18 Rudder pedal bar
19 Rotary oil delivery pipe
20 Oil tank
21 Fuel tank, capacity 7 Imp gal (32 l)
22 Gun mounting strut
23 Fuel filler cap
24 Top longeron
25 Upper cabane struts
26 Bracing wire turnbuckle
27 Warp control wire pulley
28 Windscreen
29 Hotchkiss 8-mm machine gun
30 Ammunition magazine guide
31 Spare magazines
32 Pivotal coaming
33 Engine instrument
34 Pilot's seat
35 Fuselage diagonal braces
36 Rear spar, control cable fairing
37 Cockpit shoulder fairing
38 Headrest
39 Tapered fuselage rear bays
40 Fuselage upper longerons
41 Horizontal spacers
42 Lower longeron formers
43 Tailplane front fairing
44 Stainless steel trailing edge
45 Fin leading edge
46 Rudder hinge bracket
47 Rudder counterpoise
48 Wire trailing edge
49 Tailplane construction
50 Tailplane trailing edge
51 Fin/tailplane fairing
52 Hinged tailplane spar
53 Elevator control horn
54 Tailplane hinge cables
55 Tailplane bracing
56 Rudder neutral horn fairing
57 Skid mounting strut
58 Tailskid
59 Skid rubber shoe
60 Flexible tailskid spring
61 Fuselage longerons
62 Stringer fixing former
63 Fuselage centre longeron
64 Vertical spacers
65 Tailplane centre-frame
66 Fuselage diagonal wire bracing
67 Wing trailing edge
68 Flexible rear spar
69 Upper wing panel cables
70 Wing diagonal wire bracing
71 Wing stringers
72 Raked wing tip construction
73 Rear main spar
74 Wing rib construction
75 Front spar bracing wire
76 Fin leading edge
77 Lower wing control cable
78 Upper control cable pulley
79 Wing root hinge mounting
80 Main undercarriage rear strut
81 Pneumatic wheel
82 Tyre valve access hole
83 Wheel spokes
84 Undercarriage fairing
85 Spring axle beam
86 Undercarriage centre pylon mounting
87 Stabilizer
88 Elastic cord shock absorber
89 Aluminium wheel rim
90 Starboard main wheel

Above A standard production Type N of France's Aviation militaire. The Hotchkiss machine gun can clearly be seen protruding from between the upper cabane struts, as are the deflector plates on the propeller. Adequate flying other than straight and level was a task of difficulty, requiring adjustment progressively with height and at about 10,000 ft (3,050 m) a steep banking turn could not be effected without stalling. Pilots likened the gliding angle of the Type N to that of a brick.

Sopwith Scout (February 1916)

The first single-seat military aircraft were described as 'scouts' and were intended for use precisely in that capacity as high-speed reconnaissance aircraft. As the air war evolved, the term single-seat scout took on the connotation of *fighter*, however, and the first British single-seat aircraft designed from the outset to bring a synchronised gun to bear as a fighter was to carry the official appellation of Sopwith Scout. In the event, this mundane designation was to give place unofficially but universally to the frivolous but affectionately bestowed sobriquet of Pup.

Owing much to a small, single-seat aircraft built for the personal use of Harry G. Hawker and embodying all the essential elements that were to be incorporated in the Pup, the prototype fighter was flown for the first time in February 1916, and was classic in its simplicity, both aerodynamic and structural. Of wooden construction, with two-spar mainplanes forming a single-bay wing cellule and a wire-braced box girder fuselage typical of the period, the Pup was much more robust than its lightweight str. cture and delicacy of line suggested. Its most signif cant feature was its centrally-mounted machine gun synchronised to fire through the propeller disc by means of a Sopwith-Kauper interrupter system.

Immediately recognised as a brilliant success, the Pup was ordered by both the RFC and RNAS, the former officially naming it Scout on 31 July 1916, and arrived in France at the end of 1916. Offering impeccable handling and being almost vicious, with harmonious and effective controls, the Pup immediately endeared itself to the pilots. Its performance was surprising y good in view of the low power of its engine and fully adequate for the combat demands of early 1917. It was more than a match for the contemporary Albatros D I and D II, offering a much smaller turning circle and the invaluable abi ty to me ntain h gh, in turns, even at cons derable a. itudes. It was this outstanding quality, ha oncealed the Pup to survive in France until the end of 1917 although such was the tempo of fighter development that by mid-year, it had already been outclassed in al. respects other than manoeuvrability. Nevertheless, despite withdrawal from the Western Front, the Pup remained in production until the Armistice in November 1918, albeit for use only by training units, the tota. quantity delivered (although the figure cannot now be stated with exactitude) being around 1,770 aircraft.

SPECIFICATION: Sopwith Scout (Pup)

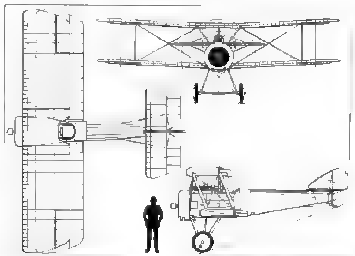
Power Plant: One Le Rhône 9C nine-cylinder rotary air-cooled engine rated at 80 hp at 1,200 rpm for take-off. Two-bladed Lang fixed-pitch wooden propeller. Internal fuel capacity, 18 5 Imp gal (84 .)

Performance: Max speed, 111 5 mph (179 km, h) at sea level, 108 5 mph (171 km h) at 6 500 ft (1 980 m), 104 5 mph (168 km h) at 10,000 ft (3 050 m), 94 mph (151 km, h) at 15,000 ft (4 570 m), time to 5 000 ft (1 525 m) 5 16 min, to 10,000 ft (3 050 m), 13 18 min; service ceiling 17,500 ft (5 335 m); endurance 4 hrs

Weights: Empty 787 lb (357 kg); loaded, 1 099 lb (498 kg).

Dimensions: Span 26 ft 6 in (8.08 m); length 19 ft 3¾ in (5.89 m); height 9 ft 5 in (2.87 m); wing area, 254 sq ft (23 59 m²).

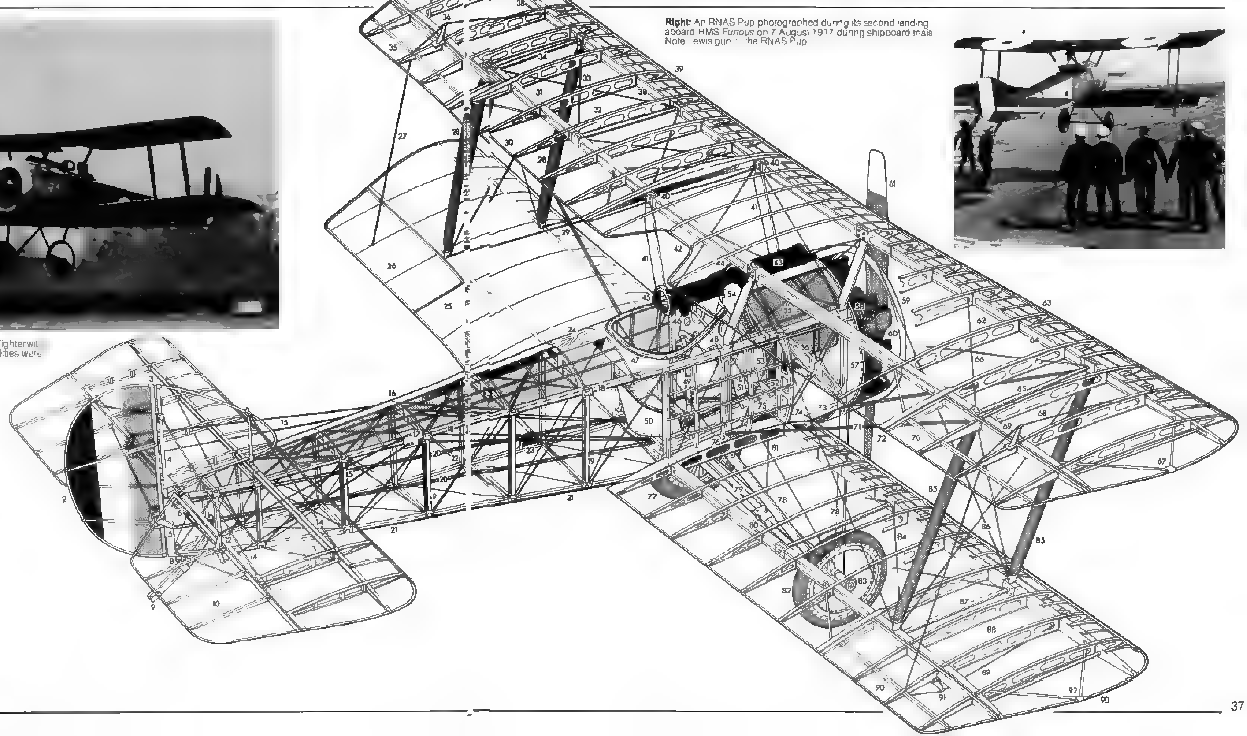
Armament: One 0 303-in (7,7-mm) Vickers machine gun with 500 rounds (RNAS version) One 0 303-in (7 7-mm) Lewis machine gun firing upwards with 297 rounds and (some) provision for eight Le Prieur rocket missiles (usually as alternative to machine gun)



Key to Sopwith Pup

1 Fabric covering, port elevator
2 Fabric covered rudder
3 Light tubular steel fin and rudder construction
4 Rudder post
5 Rudder mechanic crank
6 Tailskid weight shock absorber
7 Wooden tailskid
8 Tailskid hinge mounting
9 Sea-gulled stirrup
10 Starboard elevator
11 Elevator hinge bar
12 Elevator operating crank
13 Tailplane attachment fitting
14 Tailplane bracing wire
15 Elevator struts
16 Fabric covered rear fuselage top decking
17 Elevator rear spar
18 Top longeron
19 Vertical strut
20 Rudder cables
21 Bottom longeron
22 Fuselage side bracing
23 Fairing strip
24 Plywood top decking
25 Port lower mainplane fabric
26 Port lower aileron
27 Aileron operating cable
28 Mainplane struts
29 Fuselage wire bracing
30 Light steel tube trailing edge
31 Rear spar
32 Wing ribs
33 Diagonal bracing wires
34 Gun block, port
35 Port upper aileron
36 Aileron operating crank
37 Weight, diagonal bracing frame
38 Front spar
39 Leading edge construction
40 Port upper wing strut fitting
41 Wing centre section strut
42 Trailing edge cut out
43 Wing synchronised 0 303-in (7 7-mm) Vickers machine gun
44 Gun synchronising lever
45 Flexible drive hub guard
46 Gun locking lever
47 Padded cockpit coaming
48 Instrument panel
49 Control column
50 Pilot's seat
51 Cartridge ejection chute
52 Rudder bar
53 Ammunition tank
54 Ammunition feed chute
55 Petrol tank
56 Engine cowling fairing
57 Engine cowling
58 Sopwith Le Rhône rotary engine
59 Aluminium engine housing
60 Propeller hub
61 Two-bladed wooden propeller
62 Starboard upper wing ribs
63 Leading edge cut-away
64 Aileron spar
65 Spar bracing strut
66 Wing diagonal wire bracing
67 Weight, diagonal bracing frame
68 Aileron balance cable
69 Aileron operating crank
70 Starboard upper aileron
71 Inter-plane struts, wires
72 Light alloy hub boss, white
73 Engine bearing a duct
74 Alone covered fuselage framework
75 Footboards
76 Air weight belligerent identification
77 Engine mounting
78 Underframe cross tie
79 Cross beam
80 Rear side panelling
81 Upper longeron bracing wires
82 Stabilising skid
83 Tail skid
84 Longeron tube end fitting
85 Aileron cable
86 Aileron cable
87 Spar bracing strut
88 Tailplane wire
89 Aileron connecting cable
90 Tailplane lower skin
91 Aileron operating frame
92 Weight, diagonal bracing frame
93 Light tube tube struts

Above Although not classed as a fighter until six months after its introduction, flying qualities were never a passive



Right An RNAS Pup photographed during its second landing aboard HMS Furious on 7 August 1917 during shipboard trials. Note Lewis gun in the RNAS Pup

Nieuport 17 (February 1916)

Within two years of the fighter's debut as a distinct aircraft species, a multiplicity of possible configurations had been examined, including triplanes, quadruplanes and even quintuplanes. Most were to be discarded, the monoplane and the biplane emerging predominant and their respective merits becoming a subject for much controversy. There was one promising alternative, however, and this was the sesquiplane; a biplane in which the lower wing possessed less than half the area of the upper. The leading exponent of this compromise configuration was Gustave De age who established the distinctive unequal-chord sesquiplane arrangement with V form interplane strutting and single spar lower wing, a basic pattern that was to endure through successive Nieuport types.

The first single-seat fighter adhering to this configuration was the 80 hp Le Rhône-engined Nie 11 of 1915. The lower wing was little more than a faired spar, providing girder bracing to the upper mainplane but extended outboard beyond the V-strut attachment points to prove de additional lifting surface. The Nie 11 quickly acquired the affectionate sobriquet of Bébé, although this was subsequently to be applied to all Nieuport sesquiplane single-seaters.

Derived from the Nie 11 by way of the unsuccessful Nie 16 with the 110 hp Le Rhône, was the similarly powered Nie 17 which flown in February 1916, possessed greater wing area and embodied various structural refinements. Entering service in the following May, it proved an outstanding success, despite a propensity towards wing shedding, and equipped every French escadrille de chasse at some time during 1916. Many early Nie 17s featured a so-called cône de pénétration, a hemispherical fixed fairing mounted on an extension of the stationary crankshaft, and the Nieuport fighter was considered to establish new standards of efficiency in its class.

By late July 1917, the day of the Nie 17 over the Western Front was past. Rather than design an entirely new replacement, however, Delage obsessively persisted with the refinement of what was by now a manifestly outmoded basic design. The Nie 17bis with a 130 hp Clerget 9B engine and fully faired fuselage sides, the Nie 23 scarcely distinguishable from the Nie 17 and the Nie 24, none could match contemporary Spads. Thus the Nieuport sesquiplanes were to remain more or less in eclipse until the end of WWI. Total production of all Le Rhône-engined Nieuports reached approximately 7 200 aircraft.

SPECIFICATION: Nieuport 17 C.1

Power Plant: One Le Rhône 9Ja nine-cylinder air-cooled rotary engine rated at 113 hp at 1 200 rpm for take-off. Two-bladed fixed-pitch wooden propeller. Internal fuel capacity 17·6 Imp gal (80 l).

Performance: Max speed, 103 mph (165 km/h) at sea level, 99 mph (160 km/h) at 6,560 ft (2 000 m), 96 mph (154 km/h) at 9 840 ft (3 000 m); time to 6,560 ft (2 000 m) 6·83 min, to 9,840 ft (3 000 m) 11·5 min, service ceiling 17,390 ft (5 300 m), endurance, 1 75 hrs.

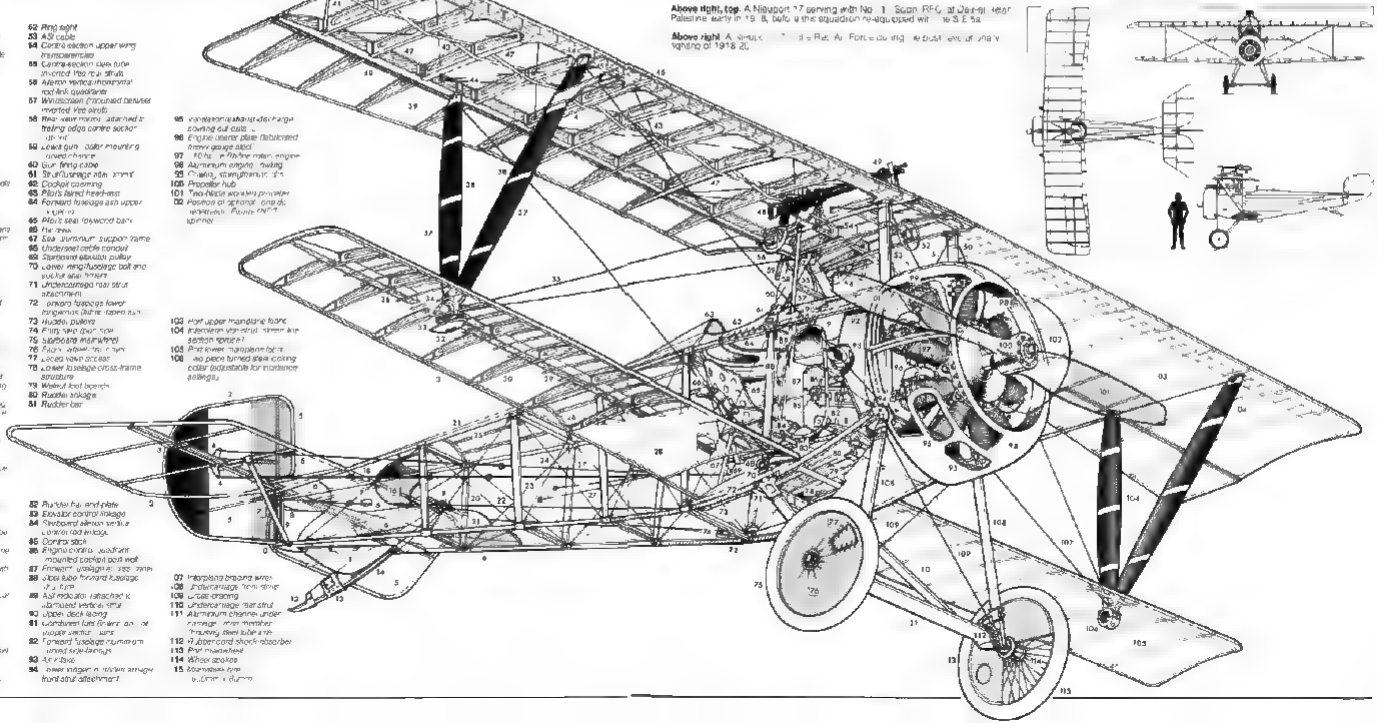
Weights: Empty, 825 lb (375 kg), loaded 1 232 lb (560 kg).

Dimensions: Span, 26 ft 9 in (8 16 m); length, 19 ft 0¼ in (5,80 m); height 7 ft 10 in (2,40 m); wing area, 158 8 sq ft (14 75 m²).

Armament: One 7 7-mm Vickers synchronised machine gun or one 7,7 mm Lewis machine gun with three 97 round ammunition drums.

Above right, top: A Nieuport 17 serving with No 1 Squadron RFC at Dekeila, near Palestine early in 1918, both of the squadron's re-equipped with the SE 5a.

Above right: A Nieuport [illegible] of the Rif Air Force during the dust devil of July 1925 in 1918 [illegible]



Key to Nieuport 17

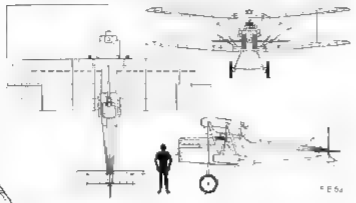
1 Fabric covered elevator
2 Light tubular steel tail surface framework
3 Stationary outer elevator unit
4 Elevator operating frame
5 Fabric covered rudder
6 Elevator cables
7 Tailplane brace strut
8 Rudder operating chains
9 Fuselage stringers
10 Rudder lower corner
11 Tailskid spring mounted on plywood covered
12 Skid spring leaf steel
13 Clamp
14 Wooden shoe
15 Port elevator outboard
16 Rear fuselage ply diagonal panels (inside frames)
17 Rudder cable outlets
18 Tailplane ply frame
19 Tailskid mounting plate
20 Transverse all fuselage sections
21 Rear fuselage stringer, convex lower longeron
22 Rudder cables
23 Spare vertical struts
24 Fuselage cross-bracing
25 Vertical longitudinal stringers
26 Vertical tube, [illegible]
27 Elevator cable runs upper and underside
28 Lower wing fairing
29 Tailplane [illegible] connection
30 Underside wing ribs through wing ribs
31 Spar [illegible]
32 Aluminium underwing socket fairing (with recessed retaining bolt)
33 Wing panel, [illegible] for [illegible] attachment
34 Interplane strut steel socket attachment, welded to metal [illegible]
35 Interplane bracing wires
36 [illegible] wood key
37 Metal-fabric covered [illegible]
38 Strengthening tape
39 Stationary aileron
40 Aileron leading edge, [illegible] opening shaft
41 Wing diagonal bracing [illegible]
42 Upper wing rear box spar, [illegible] with hardwood key
43 Wing [illegible]
44 Interplane strut, [illegible]
45 ASI
46 Leading-edge spruce and [illegible]
47 Control stick, [illegible]
48 Wing-mounted Lewis gun
49 Lewis gun [illegible]
50 Centre section cross tube [illegible]
51 Centre section cross braces
52 Ring sight
53 ASI cable
54 Centre section upper wing transverse tube
55 Centre section cross tube inverted top hat strut
56 Aileron vertical/horizontal rod link quadrants
57 Wire cable (crossed tension inverted Vee strut)
58 Rear wire mounting attached to trailing edge centre section
59 Lewis gun outer mounting
60 Gun firing cable
61 Strut/fuselage attachment
62 Cockpit coaming
63 Pilot's flared headrest
64 Forward fuselage ash upper longeron
65 Pilot's seat (plywood back)
66 Fin [illegible]
67 Seat aluminium support frame
68 Undercarriage cable conduit
69 Starboard elevator pulley
70 Lower wing/fuselage bolt and socket attachment
71 Undercarriage rear strut attachment
72 Forward fuselage lower longeron (tube faired out)
73 Rudder pulleys
74 Firing wire [illegible]
75 Starboard mainwheel
76 Fuselage [illegible]
77 Lower wing access
78 Lower fuselage cross-frame structure
79 Welded foot bands
80 Rudder bridge
81 Rudder bar
82 Rudder fin and plate
83 Elevator control linkage
84 Rearward aileron vertical control rod linkage
85 Control stick
86 Engine cowling support mounted cockpit port wall
87 Forward fuselage [illegible]
88 Side tube forward fuselage [illegible]
89 Ash reducer, attached to upper vertical strut
90 Upper deck facing
91 Wooden ribs [illegible] upper vertical [illegible]
92 Forward fuselage aluminium lined side fairings
93 [illegible]
94 Lower longeron [illegible] front strut attachment
95 Vertical/horizontal rod link cover/cut out
96 Engine cowling plate (fabricated heavy gauge sheet)
97 [illegible] Le Rhône main engine
98 Aluminium engine fairing
99 Cowling, strengthening [illegible]
100 Propeller hub
101 Two-blade wooden propeller
102 Position of optional one pounder Hotchkiss [illegible] gun
103 Port upper mainplane fabric
104 Interplane vertical steel tube section spacer
105 Port lower mainplane fabric
106 Two piece turned steel locking collar adjustable for incidence settings
107 Interplane bracing wires
108 Undercarriage front strut
109 Wire bracing
110 Undercarriage rear strut
111 Aluminium channel under fairings, [illegible] trailing, steel tube [illegible]
112 Rubber cord shock-absorber
113 Pair mainwheel
114 Wheel spokes
115 Mainwheel tyre [illegible]

RAF S.E. 5 (November 1918)

Functional optimization from mid-1916 hastened the emergence of the fighter from a truncated infancy, its translation from scout with combat capability, to fully-fledged fighting machine. In Britain, the struggle to exceed or at least match the performance capability of the newer enemy fighters being fielded resulted in two new types, the Camel and the S.E.5 which evolved in parallel, flew as prototypes within five weeks of each other.

These fighters reflected philosophies as different as their appearances. The Camel, characterised by squatness of form and lightness of weight, was to place emphasis on agility at some expense to handling. The S.E.5, on the other hand, was rakish, angular and heavy by standards of the day; it was to have none of its contemporary's waspish sensitivity, its emphasis being on tractability. Indeed, the S.E.5 was a compromise *between* agility and tractability, handling characteristics being, from certain aspects, the antithesis of those of the Camel.

The aim of H.P. Folland and the Royal Aircraft Factory team was to design around the brilliant new Hispano-Suiza V-8 engine a robust fighter capable of being flown with a reasonable degree of safety by pilots of limited experience. Although intended for the 200 hp geared Hispano-Suiza 8B engine, the prototype, flown on 22 November 1916, and a comparatively small initial production batch (S.E.5a) had the 150 hp direct-drive Hispano-Suiza 8A. Subsequent aircraft (S.E.5a's) were mostly fitted with either the intended Hispano-Suiza or the similarly-rated direct-drive Wolseley Viper. At a time when an armament of twin belt-fed synchronised guns was becoming vogue, the S.E.5 opted for one synchronised gun and another on a Foster mounting firing over the wing.



Fundamentally sound, the new fighter's early service was nevertheless marred by failures of the upper mainplane centre section, a problem exacerbated by engine reduction gear and gun synchronisation difficulties. But once these tribulations were overcome, the S.E.5 was to prove one of WWI's most competent fighters, and 5,205 S.E.5a's and 5a's were to be manufactured.

Unlike the Camel, the S.E.5 proved a forgiving aeroplane, tolerant of inexperienced pilots. Control forces about all three axes were light; there was some adverse aileron yaw, but stalling characteristics were totally innocuous. It was usefully manoeuvrable yet stable enough to facilitate accurate shooting, and if it lacked anything in agility it more than compensated in the liberties that it permitted without risk of structural failure. It was more than coincidence that most of the RFC's top-scoring pilots flew the S.E.5a.

SPECIFICATION: S.E.5a

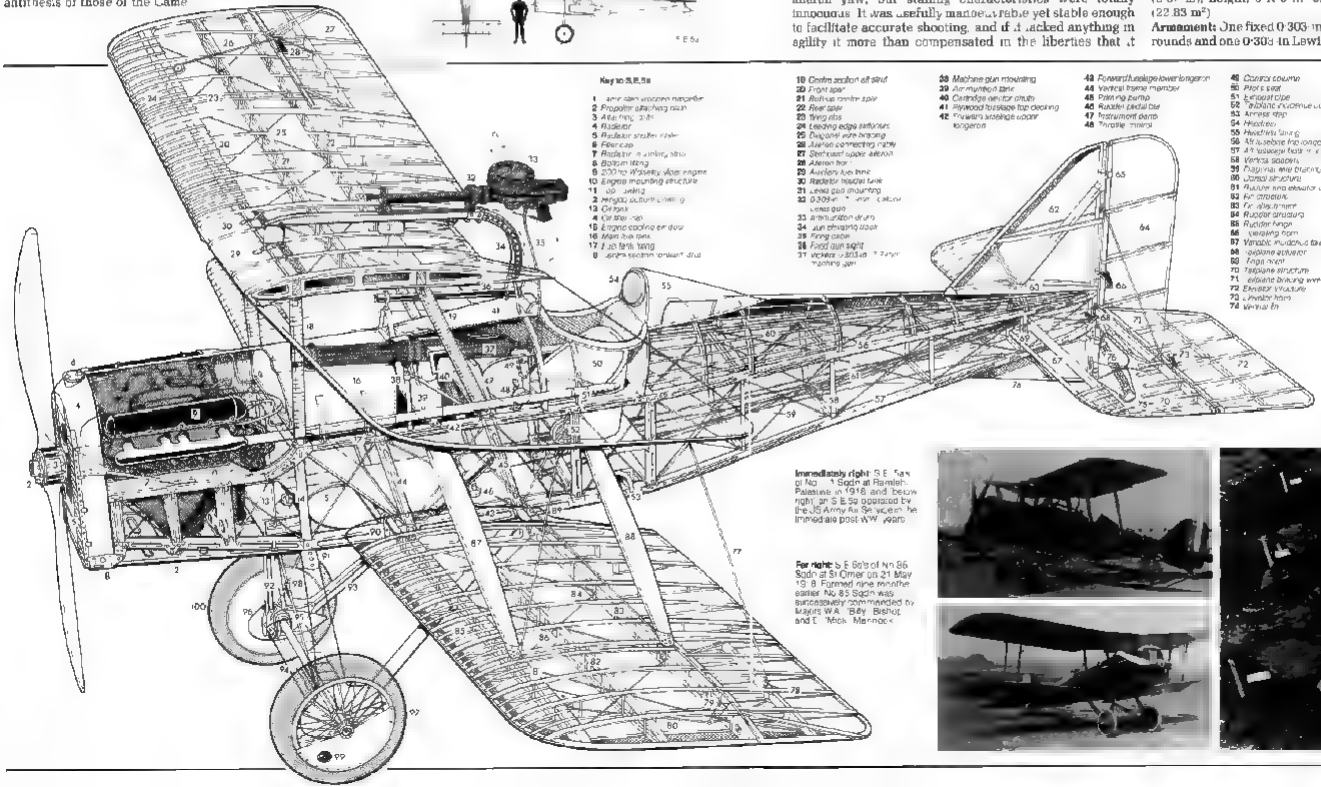
Power Plant: One Wolseley W.4a Viper eight-cylinder water-cooled vee engine rated at 215 hp at 2,100 rpm for take-off. Two-bladed fixed-pitch wooden propeller. Internal fuel capacity 35 Imp gal (159 l).

Performance: Max speed, 138 mph (222 km/h) at sea level, 126 mph (203 km/h) at 10,000 ft (3,050 m), 123 mph (198 km/h) at 15,000 ft (4,570 m); time to 5,000 ft (1,525 m), 4·92 min; to 10,000 ft (3,050 m), 11·0 min; to 15,000 ft (4,570 m), 19·92 min; service ceiling 19,500 ft (5,945 m); endurance, 3·0 hrs.

Weights: 1,459 lb (662 kg); loaded, 1,976 lb (896 kg).

Dimensions: Span, 26 ft 7½ in (8,11 m); length, 20 ft 11 in (6·37 m); height, 9 ft 6 in (2,89 m); wing area, 245·8 sq ft (22·83 m²).

Armament: One fixed 0·303-in (7·7-mm) Vickers MG with 400 rounds and one 0·303-in Lewis MG with 4 x 97-round drums.



Immediately right: S.E.5a's of No. 1 Sqdn at Ramleh, Palestine, in 1918, and below right, an S.E.5a operated by the US Army Air Service in the immediate post-WW years.

Far right: S.E.5a's of No.85 Sqdn at St Omer on 21 May 1918. Formed nine months earlier, No.85 Sqdn was successively commanded by Majors W.A. 'Billy' Bishop and E. 'Mick' Mannock.

Sopwith Camel (December 1916)

Since the birth of the fighter genus there have always been members of the class that have aroused intense controversy among their pilots: aircraft seen as anathema by some and sheer ambrosia by others. The Camel assuredly came within this category. There were pilots who acclaimed it as the best single-seat fighter to emerge from WWI; others called it a vicious killer, as equally prepared to destroy its own pilot as his adversary.

The Camel was a mercilessly unforgiving aeroplane, it is true, but to those pilots who mastered its potent peculiarities it was a dogfighter par excellence, and it was to claim the distinction of being WWI's most destructive fighter, accounting for more kills (2,790) than any other single fighter type of any nation. The Camel's lack of stability and extreme sensitivity were assets in the hands of a competent pilot and potentially fatal to the novice. It offered turning capabilities unmatched by any fighter, although if the turn was tightened too much the Camel would spin, this was an inevitable result of coarse handling.

The Camel was markedly tail heavy at full throttle and tiring to fly. It afforded its pilot poor upward vision and lacked the speed and climb rate of its later-generation German opponents. But it offered an instantaneous response to the slightest touch on the controls: it could be looped under perfect control from a low airspeed and flick rolled without any loss of altitude. Its manoeuvrability was phenomenal and this was primarily due to the concept of concentrating all the principal weight masses: engine, guns, pilot and fuel, within an extraordinarily small section of fuselage.

The first prototype was to fly as the F.1 at the end of December 1916, with the first production deliveries commencing in the following May. A snub-nosed hump-backed little aeroplane devoid of elegance, it was structurally orthodox, with single-bay fabric-covered wooden wings and a wire-braced wooden box girder fuselage, but its significance lay in its armament. For the first time a British fighter emulated the recently-established German practice of mounting a pair of synchronised rifle-calibre machine guns to fire through the propeller disc.

The somewhat humped profile engendered the epithet Camel, which was unofficial but became so popular that it was ultimately accepted. It first entered service with the RNAS and immediately afterward with the RFC, and a total of 5,597 F.1 Camels was ordered of which apparently 5,490 were delivered with the remainder being cancelled at the war's end.

SPECIFICATION, F.1 Camel

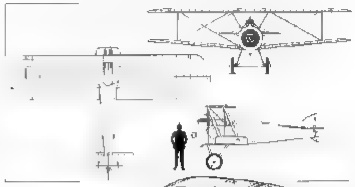
Power Plant. One Clerget 9B nine-cylinder rotary air-cooled engine rated at 130 hp at 1,250 rpm for take-off. Two-bladed fixed-pitch wooden propeller. Internal fuel capacity 37 Imp gal (168 l).

Performance: Max speed: 115 mph (185 km/h) at 5,500 ft (1,980 m), 113 mph (182 km/h) at 10,000 ft (3,050 m); 106.5 mph (171 km/h) at 15,000 ft (4,570 m); time to 6,500 ft (1,980 m), 6.0 min; to 10,000 ft (3,050 m), 10.58 min; to 15,000 ft (4,570 m), 21.83 min; service ceiling 19,000 ft (5,790 m); endurance 2.5 hrs.

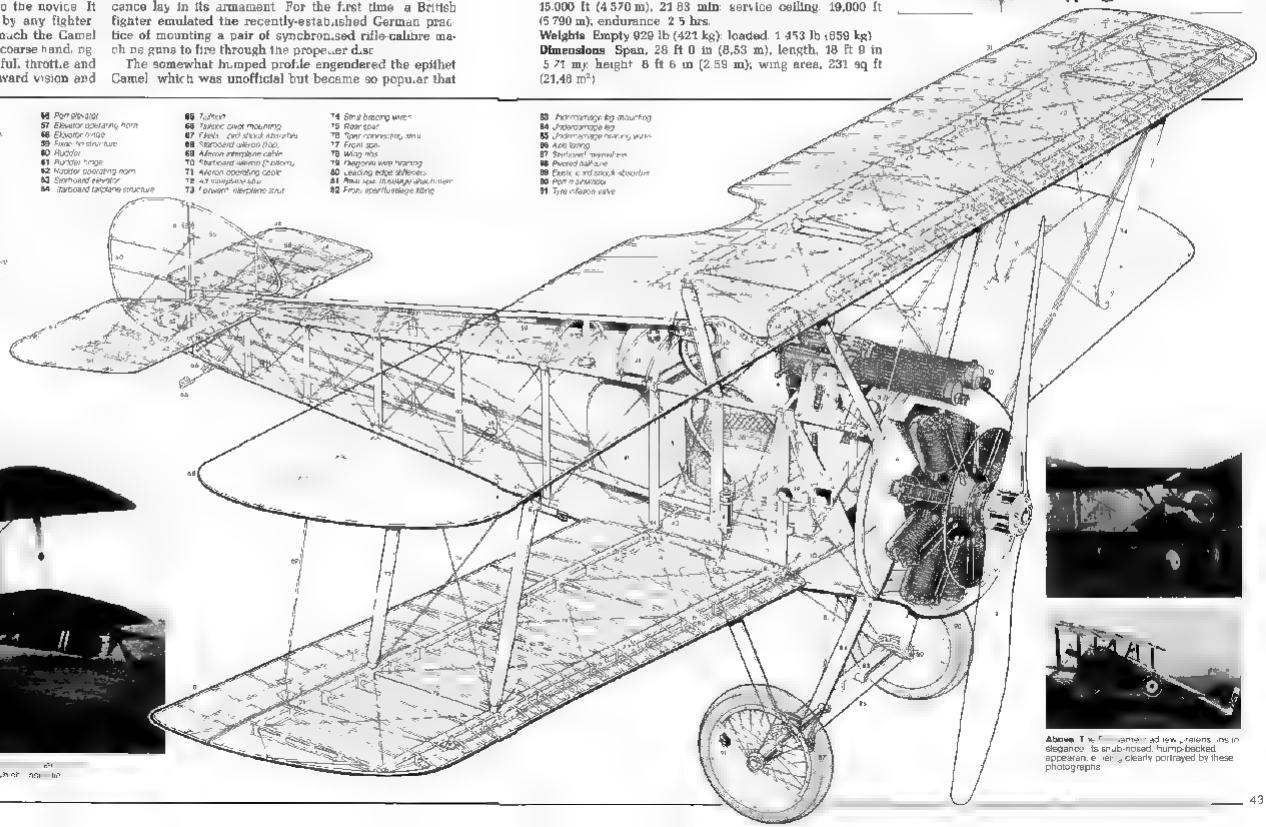
Weights: Empty 929 lb (421 kg); loaded 1,453 lb (659 kg).

Dimensions: Span, 28 ft 0 in (8.53 m); length, 18 ft 9 in (5.71 m); height 8 ft 6 in (2.59 m); wing area, 231 sq ft (21.46 m²).

Armament: Two 0.303 in (7.7-mm) Vickers machine guns with 250 rpg. Four 25-lb (11.3-kg) bombs could be carried on external racks.



Above [illegible] on a rock behind [illegible] the right.



Key to Sopwith F.1 Camel

1 Two-blade wooden propeller
2 Propeller attachment plate
3 Axle hub cap
4 Engine cowling
5 Nine-cylinder Clerget seven-cylinder rotary engine
6 Engine mounting cushions
7 Engine bearing member
8 Engine cut-away
9 Engine mounting
10 Fuselage cross member
11 Fuselage frame
12 Two synchronised 0.303 in (7.7 mm) Vickers machine guns
13 Ammunition box
14 Ammunition feed chute
15 Cartridge ejector hole
16 Gun cocking lever
17 Gun sight
18 Hinged windscreen
19 Cockpit rim cushion
20 Upper section longeron
21 Centre section bracing wires
22 Centre section main strut
23 Wing drain, fuel pressurisation pump
24 Main spar/strut joint attachment points
25 Front spar
26 Leading edge stiffeners
27 Spar operating strut
28 Rear spar
29 Innermost wing spar joint
30 Wing ribs
31 Hold aileron
32 Aileron operating horn
33 Diagonal cross bracing
34 Aileron pivot
35 Strut bracing wires
36 Interplane bracing wires
37 Rudder control operating
38 Tail basket-work seat
39 Tail operating horn
40 Main fuel tank
41 Secondary fuel tank
42 Hub filler cap
43 Cockpit cabin longeron
44 Fuselage top longeron
45 Fuselage bracing longerons
46 Vertical spacers
47 Cross member frames
48 Diagonal wire bracing
49 Tail frame
50 Tail stringers
51 Rudder cable
52 Elevator cable
53 Elevator horn
54 Port tailplane structure
55 Tailplane strut
56 Port elevator
57 Elevator operating horn
58 Elevator hinge
59 Rear fin structure
60 Rudder
61 Rudder hinge
62 Rudder operating horn
63 Starboard elevator
64 Starboard tailplane structure
65 Tailpost
66 Tailpost cleat mounting
67 Fixed tail skid shock absorber
68 Starboard aileron hinge
69 Aileron interplane cable
70 Starboard aileron pulleys
71 Aileron operating cable
72 Aileron pivot
73 Forward tailplane strut
74 Strut bracing wires
75 Rear spar
76 Spar connecting strut
77 Front spar
78 Wing ribs
79 Diagonal wire bracing
80 Leading edge stiffeners
81 Rear spar/fuselage attachment
82 Front spar/fuselage fitting
83 Undercarriage leg mounting
84 Undercarriage leg
85 Undercarriage housing wires
86 Axle fairing
87 Starboard undercarriage
88 Packed balance
89 Elastic cord shock absorber
90 Port undercarriage
91 Tyre inflation valve

Above The Sopwith Camel's distinctive lack of elegance is in its snub-nosed, hump-backed appearance, clearly portrayed by these photographs.

Albatros D V (March 1917)

As the tempo of aviation development accelerated under the pressures of war, closer attention had begun to be paid to the effects of airframe drag on fighter performance and the results were particularly apparent in the single-seat progeny of the Albatros company. Designed by Robert Thelen, these fighters established new standards in elegance, mating neatly-cowled engines with carefully streamlined semi-monocoque wooden fuselages.

The first of the genus, the D I and D II, had had an immediate impact on the air war upon arrival at the Front almost simultaneously in September 1916, being the first fighters produced in quantity to mount twin synchronised guns and the first to employ the excellent Mercedes D III engine. Their successor, the D III, had discarded their robust parallel-strutted single bay wing cellule in favour of the lighter, lower-drag Nieuport style sesquiplane cellule, appearing at the Front in December 1916. Representing an attempt to achieve higher performance with the same engine and without sacrificing manoeuvrability, the D V flown as a prototype in March 1917, was essentially a refinement of this basic design.

Utilising a lighter, less sturdy structure, the D V supplanted the near-rectangular fuselage cross section of its predecessors with a new elliptical section and arguably carried WWI fighter aerodynamic refinement to its ultimate. Reaching the Jagdstaffeln in May 1917, the D V proved structurally unsound, despite which fact 800 were built while a thorough structural reappraisal was undertaken. The end product of this reappraisal was the D Va with stronger spars, heavier ribs and additional fuselage members, which entered service in October 1917.

The heavier weight of the D Va without commensurate power increase resulted in some performance degradation, but it was still a formidable opponent when flown by a skilled pilot and 1,612 were to be built. On 30 April 1918, 928 D Va fighters were at the Front, representing 47.8 per cent of available fighter strength, and these assumed a primary role in the German spring offensive of 1918. A modest performance gain accompanied installation of the higher-compression D IIIa engine from March 1918, but the D Va faded away rapidly with availability of the Fokker D VII from the following month.

SPECIFICATION Albatros D Va

Power Plant: One Mercedes D IIIa six-cylinder inline water cooled engine rated at 160 hp at 1,250 rpm for take-off and 180 hp at 3,280 ft (1,000 m). Two-bladed fixed-pitch wooden propeller. Internal fuel capacity, 22 Imp gal (100 l)

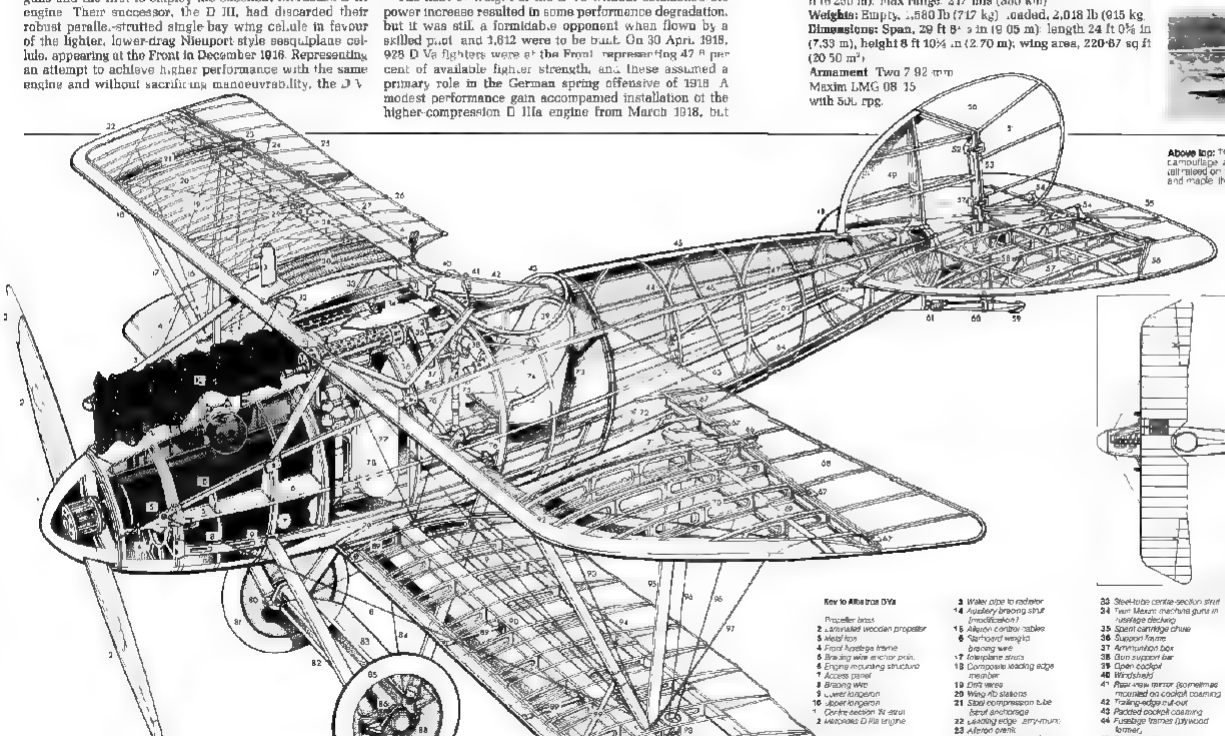
Performance: Max speed 116 mph (187 km/h) at sea level, 117 mph (188 km/h) at 3,280 ft (1,000 m), 102 mph (165 km/h) at 9,840 ft (3,000 m); time to 3,280 ft (1,000 m) 4.0 min, to 9,840 ft (3,000 m) 17.15 min, service ceiling, 20,500 ft (6,250 m); max range, 217 mls (350 km)

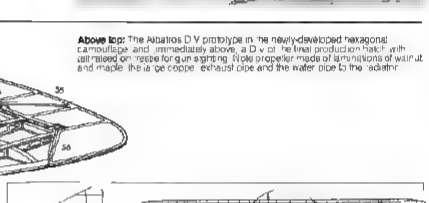
Weights: Empty, 1,580 lb (717 kg), loaded, 2,018 lb (915 kg)

Dimensions: Span, 29 ft 8½ in (9.05 m); length 24 ft 0¾ in (7.33 m), height 8 ft 10¼ in (2.70 m); wing area, 220.67 sq ft (20.50 m²)

Armament: Two 7.92 mm Maxim LMG 08/15 with 500 rpg.

Above top: The Albatros D V prototype in the newly-developed hexagonal camouflage and, immediately above, a D V of the final production batch with diffused on-waste for gun sighting. Note propeller made of laminations of walnut and maple, the large copper exhaust pipe and the water pipe to the radiator.





Key to Albatros D Va

Propeller boss
2 Laminated wooden propeller
3 Metal fins
4 Front fuselage frame
5 Bracing wire anchor pin
6 Engine mounting structure
7 Access panel
8 Bracing wire
9 Lower longeron
10 Upper longeron
11 Centre-section N strut
12 Mercedes D IIIa engine
13 Water pipe to radiator
14 Auxiliary bracing strut (modification)
15 Aileron control cables
16 Starboard wing/fuselage bracing wire
17 Interplane struts
18 Composite leading edge member
19 Drift wires
20 Wing rib stations
21 Steel compression tube fixed anchorage
22 Leading edge, carry-through
23 Aileron panels
24 Aileron actuating cables
25 Welded steel aileron frame
26 Steel wire trailing edge
27 Auxiliary spar
28 Rear spar
29 Steel compression tube
30 Twelve-unit French radiator
31 Radiator header tank
32 Combined exhaust pipe (starboard side)
33 Steel-tube centre-section strut
34 Twin Maxim machine guns in fuselage decking
35 Spent cartridge chute
36 Support frame
37 Ammunition box
38 Gun support bar
39 Open cockpit
40 Windshield
41 Rear view mirror (sometimes mounted on cockpit coaming)
42 Trailing-edge cut-out
43 Padded cockpit coaming
44 Fuselage frames (plywood former)
45 Fuselage skin
46 X tube bracing strut
47 Upper longeron fairings
48 Stabilising fin/fairing
49 Fin structure
50 Rudder balance
51 Rudder frame (metal)
52 Rudder hinges
53 Rudder post
54 Elevator control horns
55 Elevator frame (metal)
56 Elevator balance
57 Tailplane structure (wooden former)
58 Under-fin
59 Skid shoe
60 Ash skid shell
61 Elastic cord shock-absorber
62 Tailplane stub attachment
63 Control cables (trailing)
64 Lower longeron fairings
65 Control cables (leading)
66 Aileron panels
67 Wooden hinge blocks
68 Welded steel aileron frame
69 Rear spar
70 Plywood wing ribs
71 Strut anchorage
72 Entry step
73 Plywood bulkhead
74 Pilot's seat
75 Control column
76 Rudder pedals
77 Interplane bracing wires
78 Fuel tank
79 Wing stub
80 Starboard wheel
81 700 mm × 100 mm tyre
82 Axle
83 Compression strut
84 Undercarriage bracing
85 Pad tyre
86 Metal retaining strap
87 Access panel
88 Elastic cord shock-absorber
89 Forward strut compression cones
90 Wing spar
91 Aileron cables
92 Upper mainplane front spar
93 Interplane bracing wire
94 False rear spar (not anchored)
95 Aileron control cables
96 Aileron control cables
97 Pilot weight bracing wire
98 Aileron control pulley housing
99 Auxiliary bracing strut (modification)
100 Lower wing structure

Spad 13 (March 1917)

A trend towards heavier, more powerful and, in consequence, less agile, more stable single-seat fighters had begun to make itself apparent with the service début in the autumn of 1916 of the first of the acronymically dubbed Spads powered by the superb, albeit somewhat refractory, Hispano-Suiza V-8 engine. Designed by Louis Béchereau of the Société anonyme pour l'Aviation et ses Dérivés, the 150 hp Spad 7 had flown in April 1916, reflecting the demand for increased emphasis on level speed and dive capabilities at some expense to manoeuvrability resulting from combat experience over the Western Front.

The Spad 7 had made a noteworthy impact on the air war, but by the beginning of 1917 had lost its edge with the appearance of faster, more heavily armed adversaries in the see-saw battle for aerial superiority. Thus, another turn in the upward weight and power spiral was taken by its successor, the Spad 13 with twin gun armament and a geared 200 hp Hispano-Suiza engine flown late in March 1917. The new fighter bore a close family resemblance to its predecessor, retaining many characteristic features, such as the oval car-type frontal radiator with its vertical venetian-blind shutters for temperature control, but it was in fact a larger, sturdier and structurally very different aeroplane.

Despite the urgency attached to replacing the out-classed Nieuport sesquiplanes and Spad 7s, the Spad 13 was somewhat slow in reaching the Aviation militaire, only 25 having been delivered by August 1917 and no more than 372 being on strength eight months later. This delay was in part, due to the ailments suffered by its geared engine, defects which did not initially permit the full exploitation of the Spad 13's performance potential. At first, the Spad 13 failed to obtain universal approbation. Cockpit vision was poor, it was difficult to handle at low airspeeds, it possessed a dauntingly high glide angle, it had to be literally flown onto the ground and it was prone to ground looping. Its manoeuvrability, too, was somewhat deficient, but it was one of the fastest fighters of its day, it could out-dive most, if not all, its contemporaries and it was perhaps the sturdiest fighter of WWI.

The Spad 13 came into its own as the air war reached its zenith. It could not compete effectively in a turning battle with such adversaries as the Fokker D.VII, but then it was not conceived for the classic dogfighting mode of combat. Once its pilots had learned to take full advantage of its high level speed and dive capabilities, accustoming themselves to its tail heaviness, tendency to hunt in a turn and stiffness of control response, the Spad 13 was to establish an enviable combat record.

No fewer than 8,472 Spad 13s were ordered from the French aircraft industry, but only some 7,300 had been completed when production terminated in 1918.

SPECIFICATION: Spad 13 C1

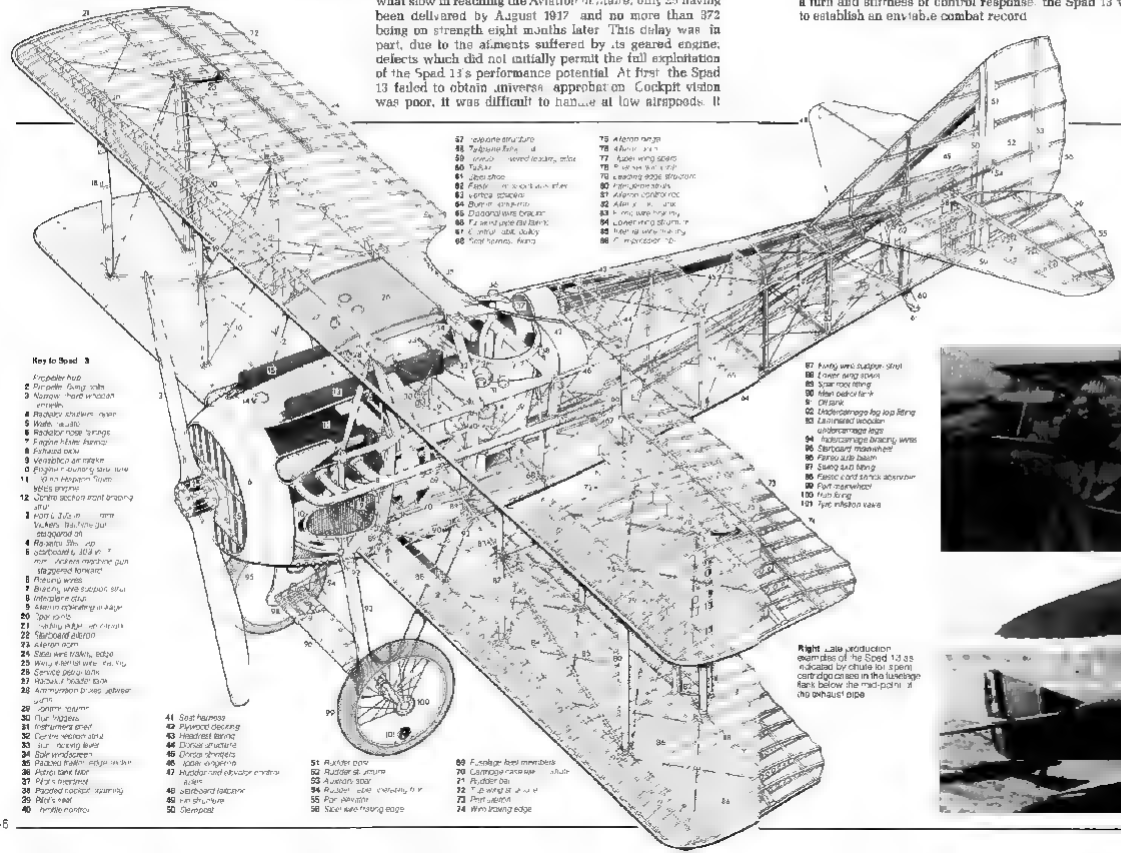
Power Plant: One Hispano-Suiza 8BEa eight-cylinder water-cooled vee engine rated at 220 hp at 2,100 rpm for take-off. Two-bladed Chauvière 22.2H wooden fixed-pitch propeller. Internal fuel capacity, 30 Imp gal. (136 l).

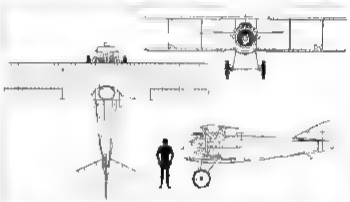
Performance: Max speed, 132.5 mph (213 km/h) at 6,560 ft (2,000 m); 131 mph (211 km/h) at 9,840 ft (3,000 m), 127 mph (205 km/h) at 13,125 ft (4,000 m); time to 3,280 ft (1,000 m), 2.5 min, to 6,560 ft (2,000 m), 5.17 min, to 9,840 ft (3,000 m), 8.33 min; service ceiling, 22,310 ft (6,800 m); endurance, 1.85 hrs.

Weights: Empty, 1,326 lb (601 kg); loaded, 1,886 lb (856 kg).

Dimensions: Span, 26 ft 6 in (8.08 m); length, 20 ft 6 in (6.25 m); height 8 ft 8½ in (2.60 m); wing area, 217.43 sq ft (20.20 m²).

Armament: Two 7.7-mm Vickers MGs with 400 rpg.





Right: Late production examples of the Spad 13 as indicated by chute for spent cartridge cases in the fuselage flank below the mid-point of the exhaust pipe

Fokker Dr I (June 1917)

Above: [illegible] Fokker Dr I, flown by Walter Blass of the [illegible] Jagdgeschwader, Ostende, August 1917, illustrating the tight wire [illegible] by No. 56 Sqdn RAF

Seen in its fighter context as a formula for combining good climbing qualities with extreme latera manoeuvrability made possible by an exceedingly small overall wing span the triplane was an aberration from the mainstream of fighter deve opment It was to enjoy a brief heyday n 1917 and be obsolescing before that year s end. Indeed, of many fighter triplanes developed, but two were to see combat

Triplane nvestigation in Germany dated from aviation's early pioneering days, but the catalyst n its further development for the fighter role was provided by the February 1917 operational debut of the Royal Naval Air Service's Sopwith Triplane The *Fliegertruppen* were started by the remarkable manoeuvrability and climb rate demonstrated by the Sopwith Germany being panicked nto launching a massive single-seat fighter triplane development effort, which, with the sole exception of one type, the Fokker Dr I, was to prove an abysma failure. The Dr I was thus conceptuaiy unoriginal in being engendered by he Sopwith, but it nevertheless embodied some highly innovatory features

Designed by Reinhold Platz, the prototype at that time known as the D VI, Fokker having still to adopt V series designat ons for experimental aircraft was an outstandingly compact triplane with *verspannungslos* (literally "without bracing"), or cantilever wings dispensing with flying, landing and incidence wires, the necessary strength being imparted by an origina, single-spar arrangement, which was actually two boxspars joined vertically The fuselage was of welded steel tubing with transverse bracing to form a rigid box-girder structure. Wing oscillation in certain flight regimes dictated introduction of thin, non-structura, spruce I-type interplane struts to provide the desired rigidity

Enjoying the patronage of no less a personality than Manfred *Freiherr* von Richthofen the triplane was ordered nto production on 14 July 1917 two prototypes being tested at the Front in the following month by von Richthofen and Werner Voss Production Dr I reached the Front from October proving very sensitive about all axes and most taxing to fly The Dr I nevertheless, possessed superlative aerobatic qualities and if a slow low-altitude performer, it made a dangerous adversary with a skilled pilot at its controls Its manoeuvrability was arguably second to no other fighter In developing the Dr I however the *Fliegertruppe* had not comprehended the inherent limitat ons of the triplane configuration and its early demise was inevitable only 320 fighters of this type being built

SPECIFICATION Fokker Dr I

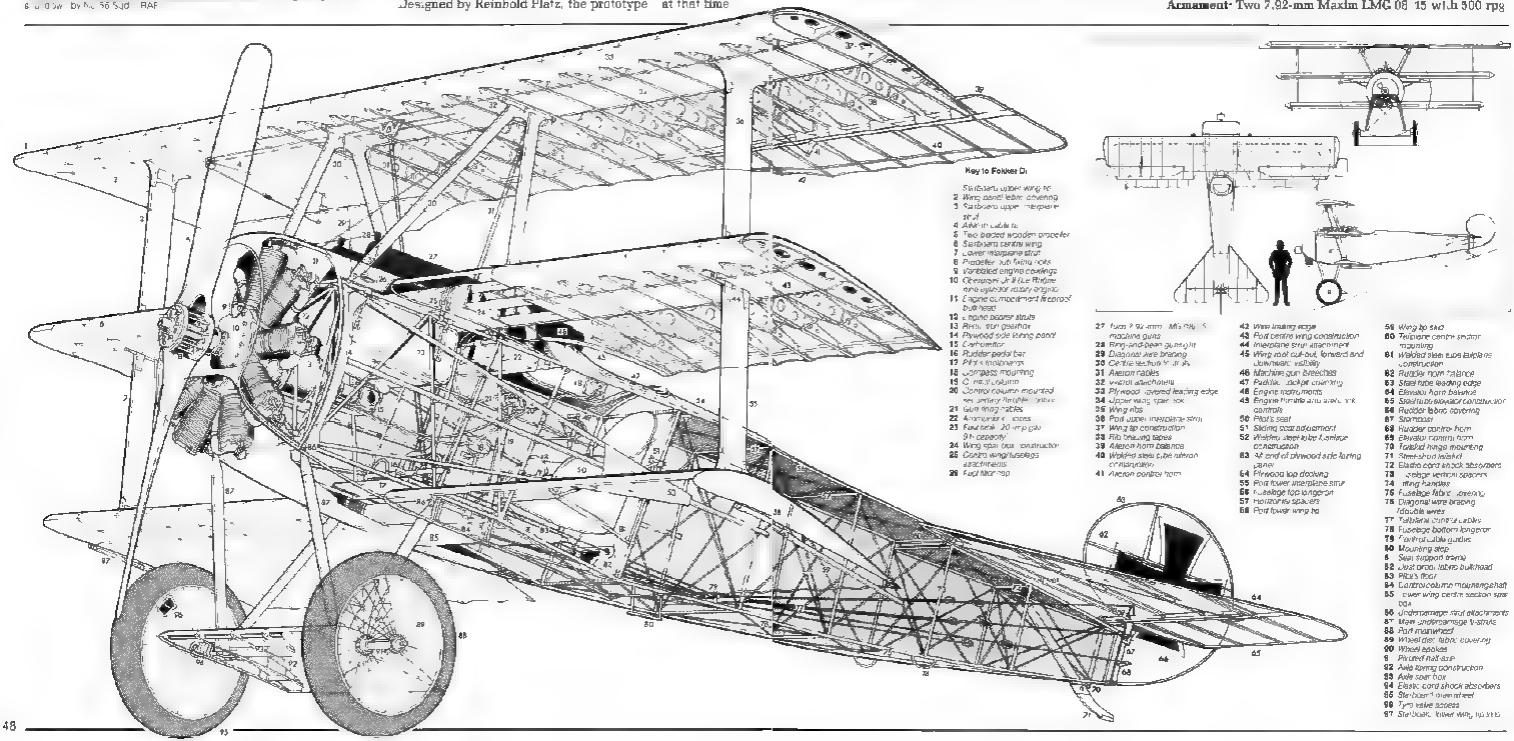
Power Plant: One Oberursel Ur II nine-cylinder rotary air-cooled engine rated at 110 hp at 1,200 rpm for take-off Two-bladed fixed-pitch wooden propeller Internal fuel capacity, 20 Imp gal (91 l).

Performance, Max speed, 115 mph 185 km h) at sea level, 102 5 mph (165 km h) at 13,125 ft (4 000 m); initial climb, 1 800 ft, min (9,15 m, sec , time to 9,280 ft (1 000 m), 2 9 min, to 9,840 ft (3 000 m), 10-1 min, to 16,405 ft (5 000 m), 23 85 min range, 185 mls (300 km)

Weights. Empty, 894 lb (406 kg), loaded, 1,291 lb (586 kg).

Dimensions: Span 23 ft 7 in (7,19 m); length, 18 ft 11 in (5,77 m) he.gh, 9 ft 8 in (2,95 m): wing area, 200 86 sq ft

Armament- Two 7,92-mm Maxim LMG 08 15 with 500 rpg



Key to Fokker Dr

1 Starboard upper wing tip
2 Wing panel fabric covering
3 Starboard upper interplane strut
4 Aileron cable to
5 Two-bladed wooden propeller
6 Starboard centre wing
7 Lower interplane strut
8 Propeller hub fairing cones
9 Ventilated engine cowlings
10 Oberursel Ur II Le Rhône nine-cylinder rotary engine
11 Engine compartment firewall bulkhead
12 Engine bearer struts
13 Pilot's stick grip/hub
14 Riveted side fairing panel
15 Carburettor
16 Rudder pedal bar
17 Pilot's instruments
18 Compass mounting
19 Control column
20 Control column mounted rev ersing flexible cables
21 Gun firing cables
22 Ammunition boxes
23 Fuel tank 20 Imp gal 91 l capacity
24 Wing spar box construction
25 Centre wing fuselage attachments
26 Fuel filler cap
27 Twin 7 92-mm Maxim LMG 08 15 machine guns
28 Ring and bead gun sight
29 Diagonal wire bracing
30 Centre section N struts
31 Aileron cables
32 Control attachment
33 Plywood covered leading edge
34 Upper wing spar box
35 Wing ribs
36 Foot upon instrument stick
37 Wing tip construction
38 Rib bracing tapes
39 Aileron horn balances
40 Welded steel tube aileron connections
41 Aileron control horn
42 Wire trailing edge
43 Foot centre wing construction
44 Interplane strut attachment
45 Wing root cut-out, forward and upward visibility
46 Machine gun breeches
47 Footrest, cockpit covering
48 Engine instruments
49 Engine throttle and ignition controls
50 Pilot's seat
51 Sliding seat adjustment
52 Welded steel tube fuselage construction
53 M end of plywood side fairing panel
54 Fireproof bulkhead
55 Foot lower interplane strut
56 Fuselage top longeron
57 Horizontal spacers
58 Foot lower wing tie
59 Wing tip skid
60 Fuselage centre section mounting
61 Welded steel tube fuselage construction
62 Rudder horn balance
63 Steel tube leading edge
64 Elevator horn balance
65 Steel tube elevator construction
66 Rudder fabric covering
67 Stamped
68 Rudder control horn
69 Elevator mounting horn
70 Tubular hinge mounting
71 Steel shod leaded
72 Elastic cord shock absorbers
73 Undercarriage vertical spacers
74 Lifting handles
75 Fuselage fabric covering
76 Diagonal wire bracing (double wires
77 Tailplane control cables
78 Fuselage bottom longeron
79 Control cable guides
80 Mounting step
81 Seat support frame
82 Mast cross fabric bulkhead
83 Pilot's flying
84 Control column mounting shaft
85 Lower wing centre section spar box
86 Undercarriage strut attachments
87 Main undercarriage V-struts
88 Port mainwheel
89 Wheel disc fabric covering
90 Wheel spokes
91 Riveted hub strip
92 Axle fairing construction
93 Axle spar box
94 Elastic cord shock absorbers
95 Starboard mainwheel
96 Tyre valve access
97 Starboard lower wing tip

Fokker D VII (December 1917)

The close-in high-g manoeuvring style of fighter-versus-fighter conflict, which had become known as dogfighting, had been brought to a fine art as the aerial warfare of WWI developed. Pursuit of the agility and control finesse necessary to excel in this mode of combat was inevitably compromised, however, by demands for higher level speeds and climb rates, the fulfilment of which was possible only at some expense to manoeuvrability. Thus fighter designers constantly sought the ideal compromise between these conflicting requirements: and perhaps the supreme example of success in such was the Fokker D VII.

When committed to the Front in April 1918, with the tide of aerial warfare running strongly against Germany, the D VII revealed standards of controllability that were to become legendary standards against which new fighters were to be adjudged for a decade or more. It was not the fastest fighter at the Front during the summer and autumn of 1918, nor was it the most manoeuvrable, but it was certainly the most effective.

Inheriting some of the innovatory structural features first used by Reinhold Platz for the Dr I (see pages 48-49), the D VII had thick-section high-lift wings each built up on two wooden boxspars and dispensing with flying, landing and incidence wires; the fuselage retaining the typical Fokker wire-braced steel-tube primary structure. The first of two (V XI) prototypes was flown in December 1917, winning the D-Type contest at Adlershof in the following month. Large-scale production was immediately initiated by Fokker and by Albatros as licensee, the standard D VII with the Mercedes D IIIa engine and the D VIIF following shortly afterwards with the marginally more powerful BMW IIIa.

It was to be said of the D VII that it could translate the mediocre into the good pilot and the good pilot into an ace. If this was perhaps an exaggeration, the D VII was certainly an outstandingly easy aeroplane to fly. It was forgiving yet extraordinarily responsive: its stall was straightforward and it spun reluctantly. It remained under full control when its adversaries stalled and spun, and it could 'hang on its propeller' at angles up to 45 degrees and remain a stable gun platform. Fokker produced 661 D VIIs and Albatros built at least that many again.

SPECIFICATION Fokker D VII

Power Plant: One Mercedes D IIIa six-cylinder inline water-cooled engine rated at 160 hp at 1,250 rpm for take-off and 180 hp at 3,280 ft (1 000 m). Two-bladed fixed-pitch propeller. Internal fuel, 21 Imp gal. (95 l)

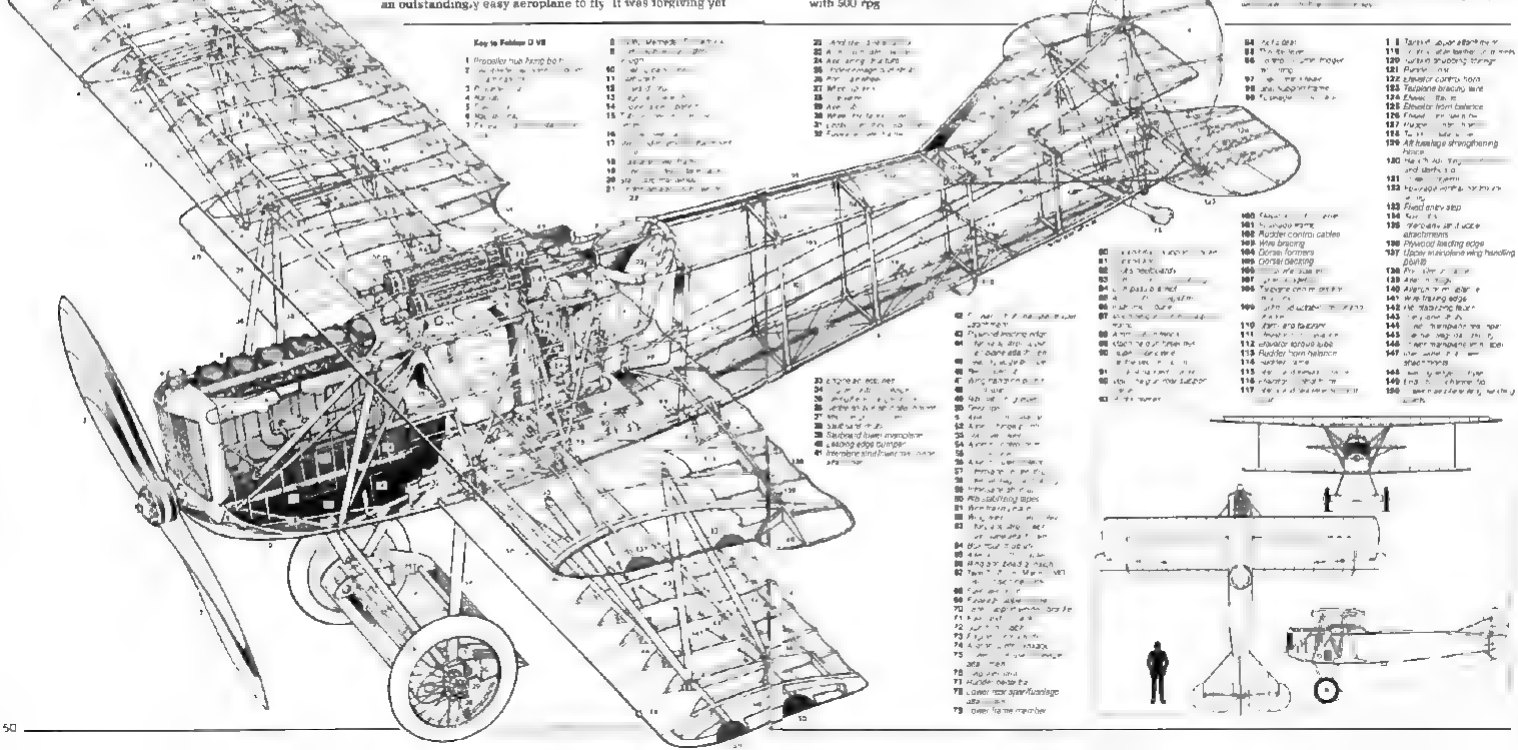
Performance: Max speed, 115 mph (185 km/h) at sea level, 116 mph (187 km/h) at 3 280 ft (1 000 m), 114 mph (183 km/h) at 6,560 ft (2 000 m), time to 3 280 ft (1 000 m), 3 8 min, to 13,125 ft (4 000 m), 18 5 min

Weights: Empty, 1,500 lb (684 kg); loaded, 2006 lb (910 kg)

Dimensions: Span, 29 ft 2½ in (8,90 m), length, 22 ft 6¾ in (6 95 m), ht, 9 ft (2,75 m); wing area, 217 44 sq ft

Armament: Two 7 92-mm Maxim LMG 08 15 with 500 rpg

Above: The Fokker D VII was to soldier on in the inventories of a number of the world's air forces, some not being finally [illegible]



Fairey Flycatcher (November 1922)

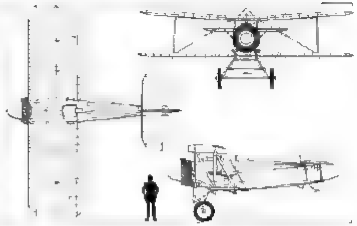
The first single-seat shipboard fighter of post WW I concept to achieve service status and the intended successor of the Nieuport Nighthar and the Parnell Panther, both of which had their origins in that conflict, the Flycatcher was aesthetically a singularly unattractive aeroplane. Its strongly individual, rather ungainly appearance belied its true character, however, for it was a superbly aerobatic fighter, with remarkably well co-ordinated controls and beautiful handling characteristics. It was to be described as having the stable docility of the Sopwith Pup mated with the response of the Sopwith Camel. To these qualities it added excellent robustness. It was the first warplane to be required by the Air Ministry to be capable of diving vertically at full power until it reached terminal velocity.

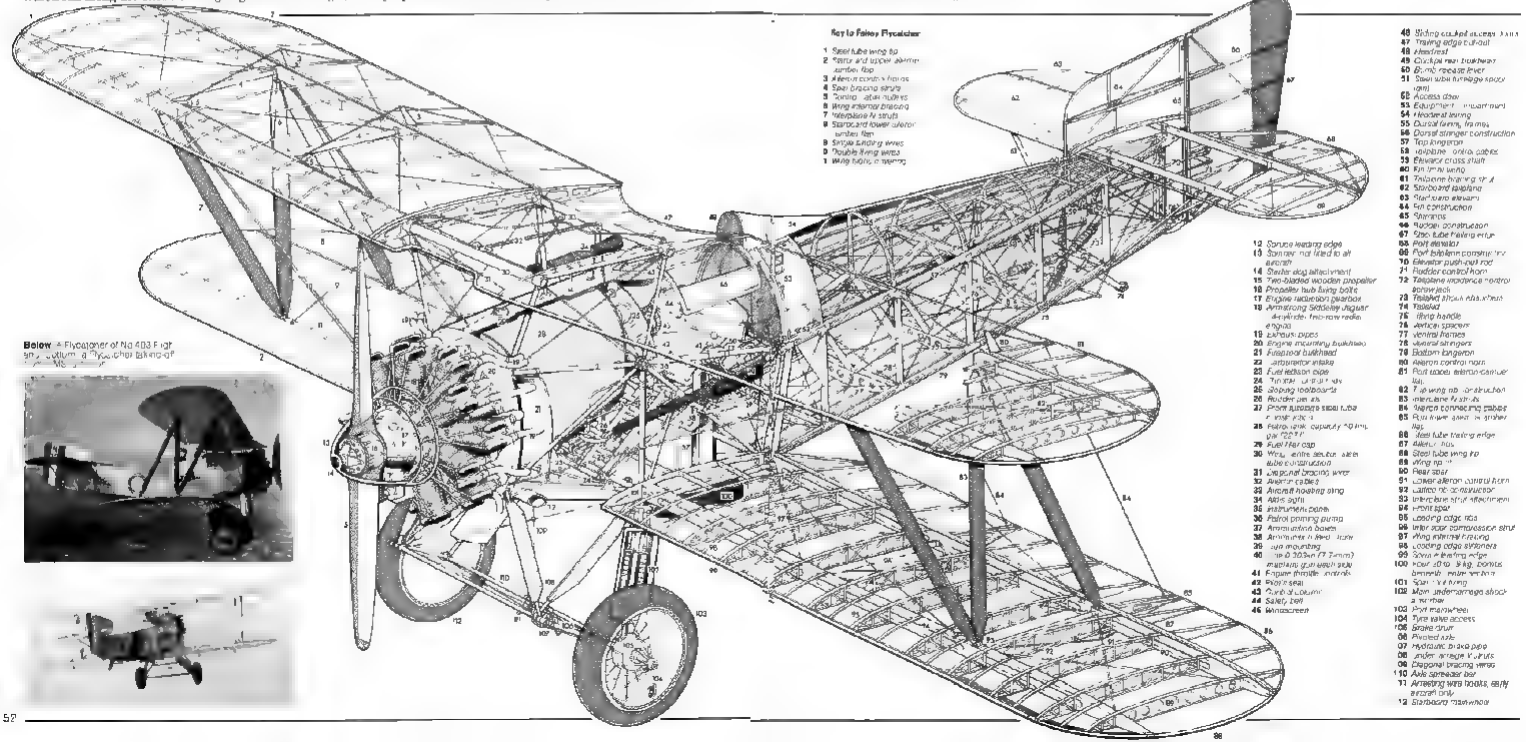
When the first Flycatcher prototype flew on 28 November 1922 ship board aviation was in its infancy; the Royal Navy possessed only one true aircraft carrier, HMS Argus. Mainly of wooden construction with fabric skinning, the Flycatcher incorporated the Fairey-patented camber-changing mechanism for the wings, which, comprising wide-chord flaps which ran along the entire trailing edges of both wings (the outer sections also serving as ailerons), shortened take-off and landing runs and steepened the glide path.

Ordered into production in 1923, the Flycatcher entered service with the Fleet Air Arm's No 402 Flight the same year; successive orders maintaining production until the 182nd and last (excluding three prototypes) was flown to Cosport on 20 June 1930. Until 1932, when it began to give place to Nimrods and Ospreys, being entirely superseded by 1934, the Flycatcher was the Fleet Air Arm's standard and only single-seat fighter, and it served on all the Royal Navy's carriers of the day, was used both as a landplane and floatplane from shore bases, and was, in fact, to be the last type capable of taking-off without catapult aid from platforms on the turrets of capital ships. It was also the last fighter capable of being utilised for so-called "slip flights" from carriers, taking-off from a 60 ft (18.25 m) tapered runway, straight from the hangar and over the bows while other aircraft were being flown from the main deck above. Among other things, it was to be remembered for the "blue note" that it emitted in a full-power dive as a result of propeller shock wave and tip flutter.

SPECIFICATION: Flycatcher I

Power Plant: One Armstrong Siddeley Jaguar IV 14-cylinder two-row radial air-cooled engine rated at 410 hp at 1,700 rpm for take-off. Two-bladed fixed-pitch wooden propeller.
Internal fuel capacity: 50 Imp gal (227 l)
Performance. Max speed, 134 mph (216 km/h) at sea level, 133 mph (214 km/h) at 5,000 ft (1,525 m), 130 mph (209 km/h) at 10,000 ft (3 050 m), 117 mph (188 km/h) at 15,000 ft (4 570 m); range at 10,000 ft (3 050 m) 311 mls (500 km) at 110 mph (177 km/h), 263 mls (423 km) at 130 mph (209 km/h); initial climb, 1 060 ft/min (5.54 m/sec); time to 5,000 ft (1 525 m) 5·92 min, to 10,000 ft (3 050 m), 9·5 min; service ceiling, 19,000 ft (5 790 m)
Weights: Empty, 2 038 lb (924 kg); normal loaded, 3,028 lb (1 373 kg).
Dimensions: Span 29 ft 0 in (8.84 m); length, 22 ft 10 in (6.96 m); height, 10 ft 0 in (3 05 m); wing area, 286 sq ft (26 76 metres²)
Armament: Two 0 303-in (7 7 mm) Vickers Mk I machine guns and provision for four 20-lb (9.07 kg) bombs beneath centre section of fuselage.





Below: A Flycatcher of No 403 Flight on a Vickers catapult on board HMS Argus

Bristol Bulldog (May 1927)

Above: A Mk II Bulldog, 5 Squadron RAF, with white tail and fuselage band, flying in formation with Gloster Gauntlets. The Bulldog was the last biplane fighter in RAF service, being replaced by the Hawker Hurricane

Successor in RAF fighter squadrons of the Siskin and Gamecock, both of which had been progressive developments of designs with origins in World War I, the Bulldog reflected a changing British attitude towards the operational use of fighters. From the early twenties, there were signs of some re-assessment of fighter requirements, a trend of thought away from the concept of standing patrols of fighters of modest performance towards the high performance fast-climbing interceptor. The catalyst was provided by the emergence of two-seat day bombers (eg, the Fairey Fox) capable of outpacing contemporary single-seat fighters, and the Bulldog was closely albeit somewhat circumstantially related to the mutating British views on this category of warplane.

Designed by Capt Frank Barnwell and of high-tensile steel strip construction, the Bulldog evolved as a private venture via proposals tendered to meet a succession of off-air specifications, and despite this being something of an interloper, emerged as the winning contender in the RAF's most hotly-contested inter-war re-equipment programme (F 9/26). Flown as a prototype on 17 May 1927, the Bulldog proved to possess excellent manoeuvrability and well-harmonised controls, a second prototype being ordered by the Air Ministry with a lengthened fuselage to improve spin recovery, this being ordered into production in August 1928 as the Bulldog II. RAF deliveries commenced in May of the following year, 312 being delivered to the service, the 49th and subsequent aircraft being Bulldog IIAs embodying some structural strengthening, revised oil system and a modified undercarriage.

The dominant RAF fighter of the early thirties, the Bulldog equipped nine squadrons, finally giving place to the Gladiator (see pages 76-77) in 1937. The Bulldog was supplied to Australia (8), Estonia (12), Siam (2), Sweden (3) and the US Navy (2), and an extensively revised development, the Bulldog IVA, intended to compete with its ultimate successor, the Gladiator, was ordered by Finland (17) in April 1936, remaining in first line Finnish service until the spring of 1940, and thus serving during the Soviet-Finnish "Winter War" of November 1939 to March 1940.

SPECIFICATION: Bulldog IIA

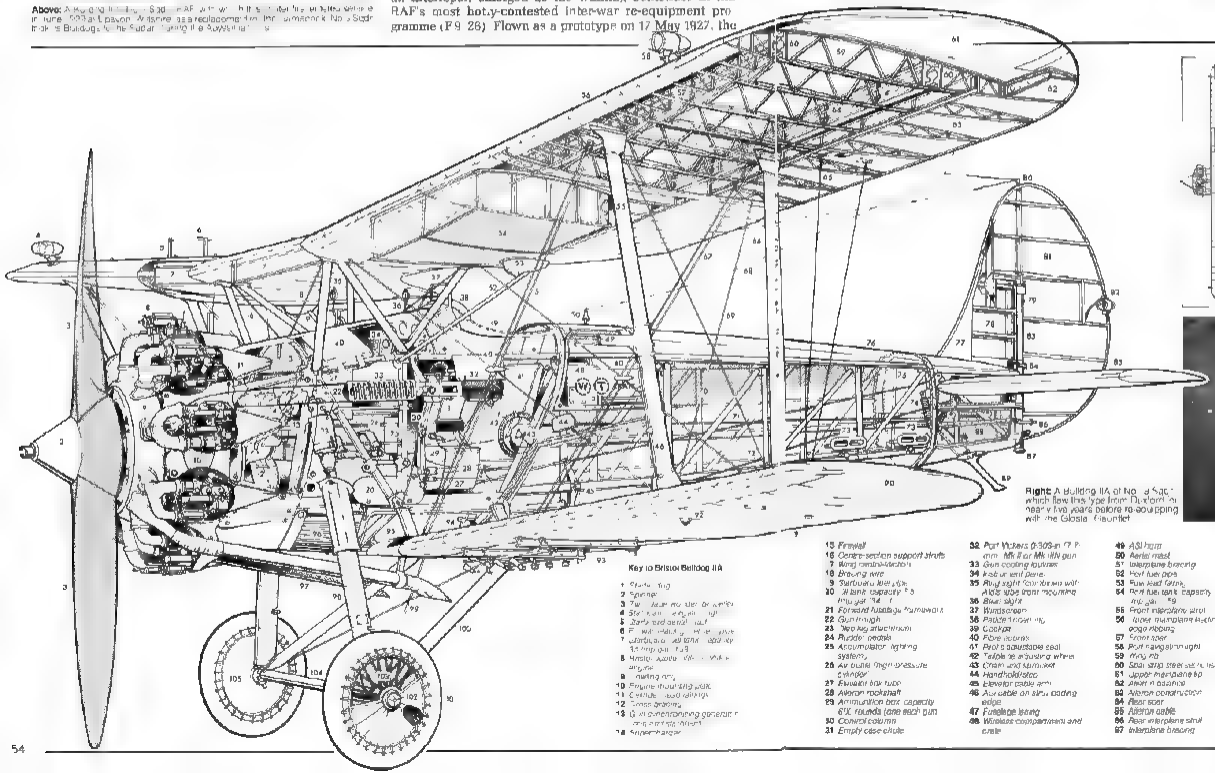
Power Plant: One Bristol Jupiter VIIF radial air-cooled engine rated at 440 hp at 1,950 rpm and 520 hp at 10,000 ft (3,050 m). Two-bladed fixed-pitch wooden propeller. Internal fuel capacity, 70 Imp gal (318 l)

Performance: Max speed 178 mph (286 km/h) at 10,000 ft (3,050 m), 162 mph (260 km/h) at 20,000 ft (6,100 m); range, 355 miles (563 km) at 15,000 ft (4,570 m); time to 20,000 ft (6,100 m), 14.5 minutes; service ceiling, 29,300 ft (8,930 m)

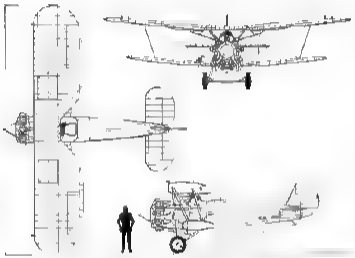
Weights: Empty 2,412 lb (1,094 kg); max loaded 3,530 lb (1,601 kg); later increased to 3,660 lb (1,660 kg).

Dimensions: Span 33 ft 10 in (10.31 m); length 25 ft 0 in (7.62 m); height, 9 ft 10 in (2.99 m); wing area, 306.5 sq ft (28.50 m²).

Armament: Two 0.303 in (7.7 mm) Vickers Mk II or Mk IIIN machine guns with 600 rounds for each gun, and with provision for four 20 lb (9.07 kg) Mk I HE bombs carried on wing racks.



Right: A Bulldog IIA of No 43 Sqn, which flew this type from Duxford in the early two years before re-equipping with the Gloster Gauntlet



Key to Bristol Bulldog IIA

1 Crankshaft
2 Sump
3 Oil cooler
4 Starter motor
5 Starter gear
6 Engine mounting
7 Ventilating air duct
8 Mixture control
9 Mating ring
10 Engine mounting bolt
11 Crankcase
12 Cross bracing
13 Oil accumulating generator
14 Engine bearer
15 Firewall
16 Centre-section support struts
17 Wing centre-section
18 Bracing wire
19 Starboard wing tank
20 Wing tank capacity 7.5 Imp gal (34 l)
21 Forward fuselage framework
22 Gun trough
23 Tail skid attachment
24 Rudder cable
25 Accumulator lighting system
26 Air bottle (high pressure cylinder)
27 Elevator bar tube
28 Aileron rocker shaft
29 Ammunition box capacity 600 rounds (one each gun)
30 Control column
31 Empty case chute
32 Port Vickers 0.303-in (7.7-mm) Mk II or Mk IIIN gun
33 Gun cooling system
34 Instrument panel
35 Rudder light (combined with tail skid and tail lighting)
36 Blind flying
37 Windscreen
38 Rudder trimmer
39 Cockpit
40 Fore-planes
41 Pilot's adjustable seat
42 Telephone in starboard wheel
43 Chain and sprocket
44 Handbrake
45 Elevator cable arm
46 Aux cable on stern cabling edge
47 Fuselage lacing
48 Wireless compartment and cable
49 ASI horn
50 Aerial mast
51 Interplane bracing
52 Port fuel pipe
53 Fuel lead fitting
54 Port fuel tank capacity 35 Imp gal (159 l)
55 Front interplane strut
56 Lower interplane bracing
57 Cross spar
58 Port navigation light
59 Wing rib
60 Spar strip steel attachments
61 Upper interplane rib
62 Chain in casing
63 Aileron construction
64 Rear spar
65 Aileron cable
66 Rear interplane strut
67 Interplane bracing
68 Aerials
69 Strut cross-bracing
70 Fuselage tubular framework
71 Undercarriage/interplane fairings
72 Flexible cable
73 Handholds with kling cord binding
74 Tailplane spring
75 Rear fuselage lacing
76 Fuselage decking
77 Tailplane
78 Fin frame structure
79 Upper rudder hinge
80 Aerial anchor point
81 Rudder frame
82 Rear navigation light
83 Rudder post
84 Control rudder hinge
85 Port tailplane
86 Lower rudder hinge
87 Support pad with trolley
88 Strut frame construction
89 Tailskid
90 Lower interplane fin
91 Port lower interplane
92 Tail-down tag
93 Light bomb racks
94 Air-driven generator (mounting saddle)
95 Cartridge-ejection tubes
96 Oil cooler
97 Exhaust pipes
98 Undercarriage
99 Cross-bracing wires
100 Fixed weight radius rod
101 "100" or "100 Barrel" Hand Aero Tyre
102 Tire valve
103 Wheel spokes
104 Axle strut
105 Wheel cover
106 Lifting track rod

Hawker Fury (March 1929)

Singularly few among combat aircraft are those that can be pronounced without equivocation as epoch-making paragons, but one such is assuredly the Fury, which carried warplane performance beyond 200 mph (322 km/h) for the first time. Representing a further stage in the trend in British fighter evolution towards the fast-climbing high-performance interceptor begun with the Bulldog (see pages 54-55), the Fury established a level of design elegance entirely new to combat aircraft and fresh standards in control sensitivity for fighters of its generation.

The Fury's handling characteristics were as near perfect by the standards of the day as could be, with light and positive aileron and rudder, and only slightly heavier elevator. It could glide and be flown straight and level hands-off, its stall was gentle and readily recoverable, and a spin could be terminated at will. These, combined with high speed and good climb-and-dive performance, while its delicacy of line belied its innate sturdiness.

Entering RAF service in May 1931, two years after the Bulldog, the Fury prototype was first flown in March 1929 as the private-venture Hornet, being re-named when purchased by the Air Ministry in the following September. Production was initiated in August 1930, the first series aircraft flying on 21 March 1931 and the first export order (for six, meanwhile having been obtained from Yugoslavia as the forerunner of purchases by Iran (24), Norway (1), Portugal (3), South Africa (7) and Spain (3). Purchases of the initial mode, for the RAF totalled 118 aircraft. These becoming Fury I, retrospectively with the debut of the Fury II, and being used as frontline fighters by three squadrons. The Fury II, which first flew on 3 December 1936 and entered service early in the following year, differed essentially in having a 640 hp Kestrel V, and augmented fuel tankage, 112 being built to complete RAF Fury procurement.

The Fury had virtually disappeared from the RAF inventory by the beginning of WWII, but the South African Furies, supplemented by 24 ex-RAF aircraft, saw some action in East Africa. Yugoslavia, too, flew Furies operationally, having procured an additional 10 aircraft from the parent company and licence-built a further 40. Although its operational achievements were dest ned to be few, the Fury was an elegant expression of the genius of Sydney Camm, one of the most notable British fighter designers of the period and the creator of the Hurricane (see pages 92-93).

SPECIFICATION Fury I

Power Plant: One Rolls-Royce Kestrel II S 12-cylinder vee liquid-cooled engine rated at 485 hp at 2,400 rpm for take-off and 575 hp at 13,000 ft (3 965 m). Two-bladed Watts B 274 wooden fixed-pitch propeller. Internal fuel capacity, 50 Imp gal (227 l).

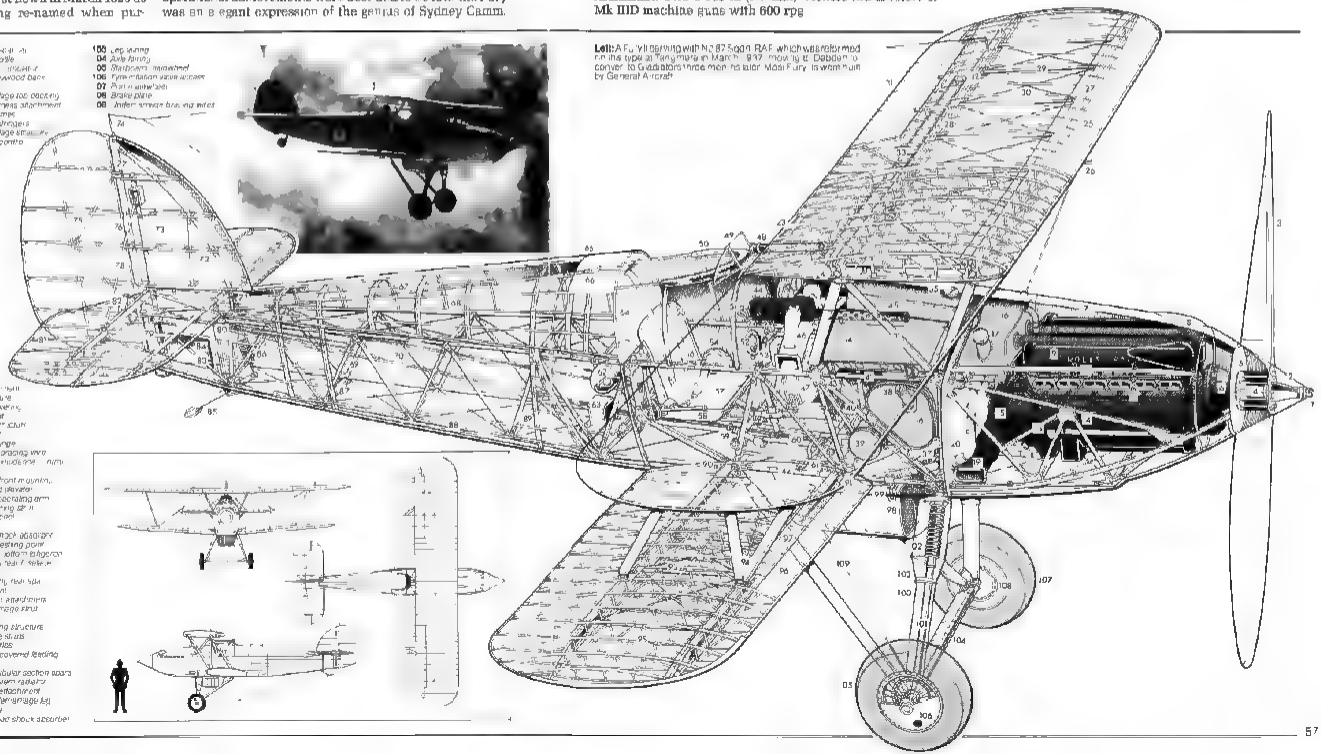
Performance: Max speed, 192 mph (309 km/h) at 5,000 ft (1 525 m), 207 mph (333 km/h) at 14 000 ft (4 270 m); range, 305 mls (491 km) at 160 mph (257 km/h); initial climb 2 380 ft/min (12.09 m/sec); time to 10,000 ft (3 050 m), 4 42 min, to 20 000 ft (6 100 m), 8·6 min; ceiling, 28,000 ft (8 450 m).

Weights: Empty equipped, 2,623 lb (1 190 kg); normal loaded, 3,490 lb (1 583 kg).

Dimensions: Span 30 ft 0 in (9 15 m), length, 20 ft 3¾ in (6,00 m), height 9 ft 8 in (2,89 m), wing area, 251 8 sq ft (23 40 m²).

Armament: Two 0·303-in (7 7-mm) Vickers Mk II (star) or Mk IIID machine guns with 600 rpg.

Above. One of the three Furies of the Portuguese Arma de Aeronautica, which supplemented the 10 aircraft ordered in addition to those they were entitled to the RAF's Fury II approximately 1 Fury II Kestrel



Left: A Fury I flying with No 87 Squadron RAF, which was re-formed from its operational training unit in March 1937, moving to Debden to convert to Gladiators, more modern but Mark Fury, in work built by General Aircraft

Key to Hawker Fury I

1 Spinner
2 Spinner
3 Watts two-bladed wooden propeller
4 Propeller attachment bolts
5 Spinner backplate
6 Propeller reduction gear
7 Engine cowling
8 Cowling fairing
9 525 hp Rolls-Royce Kestrel (1 0 engine)
10 Cowling attachments
11 Exhaust stubs
12 Front engine mounting
13 Rear engine mounting
14 Engine support framework
15 Supercharger
16 Water system header tank
17 Water system filler cap
18 Oil sump plate
19 Supercharger air intake
20 Engine bearer bolts
21 Centre section N struts
22 Wing fairing support structure
23 Wing fairing
24 Wing fairing attachments
25 Plywood-covered leading edges
26 Wing stub tubes
27 Fuselage side formation
28 Fuselage side rear spar
29 Stern planing strut
30 Wing fairing strut
31 Fin stem
32 Aerial cable
33 Aerial cable
34 Heavy oil tank 2 Imp gal (9 l)
35 Filler cap
36 Main fuel tank 15 Imp gal (68 l)
37 Tank mounting
38 Filler cap
39 Tailskid
40 Fuselage tubular framework
41 Upper longeron
42 Lower longeron
43 Wing longeron
44 Wing fuselage joints
45 Vickers 0·303-in (7·7-mm) machine guns
46 Gun barrel through oil tank
47 Cartridge ejection chute
48 Ammunition tank 600 rounds each gun
49 Sunlight
50 Pilot's windscreen
51 Padded cockpit combing
52 Throttle and mixture control levers
53 Control column
54 Instrument panel
55 Fuselage transverse control handhold
56 Spring harness
57 Harness release cable
58 Pilot's seat
59 Seat adjusting lever
60 Rudder bar
61 Rudder bar pivot
62 Tailplane bolts
63 Battery (12 volt)
64 Pocket plywood bulkhead
65 Rear fuselage fairing
66 Safety harness attachment
67 Metal frame
68 Wooden stringers
69 Rear fuselage structure
70 Tailplane centre nodes
71 Fin attachment
72 Fin attachment
73 Fairing covering
74 Aerial post
75 Rudder stop chain
76 Stonepost
77 Rudder hinge
78 Rudder trailing wire
79 Tailplane incidence mechanism
80 Tailplane front mounting
81 Starboard elevator
82 Elevator operating arm
83 Fixed trailing edge
84 Aileron spar
85 Tailskid
86 Tailskid shock absorber
87 Aircraft lifting point
88 Fuselage bottom longeron
89 Access to rear fuselage structure
90 Lower wing, rear spar attachment
91 Front spar attachments
92 Undercarriage strut attachment
93 Lower wing structure
94 Interplane struts
95 Wooden ribs
96 Plywood covered leading edge
97 Double tubular section spars
98 Wing system radiator
99 Radiator attachment
100 Wing fairing support
101 Leg strut
102 Rubber pad shock absorber
103 Leg fairing
104 Axle fairing
105 Starboard mainwheel
106 Fore-and-aft radius rod
107 Port mainwheel
108 Brake plate
109 Wheel arch fairing inlets

Curtiss P-6E (mid 1931)

In constant pursuit of increased performance the Curtiss company subjected one basic fighter design, sporting the company-assigned epithet of Hawk, to a continuous process of evolutionary development throughout the second half of the 'twenties. Designed by William E. Gilmore and George Page, the Hawk remained fundamentally unchanged from the debut of the XPW-8B in December 1924 (this, as prototype of the P-1 being effectively first of the genus) to December 1931 and commencement of deliveries of the P-6E which was to bring the era of the Hawk biplane in US Army service to its close.

During the intervening seven years, this evolutionary process in fact increased Hawk speed by a mere 30 mph (48 km/h), or 18.4 per cent, which was to seem decidedly unspectacular by comparison with the quantum performance advances to follow over the next seven years. The same time-span saw installed power increase 20 per cent, power loading decrease by 12 per cent and wing loading increase by 14 per cent.

The P-6E, an amalgam of the experimental YP-20 and XP-22, both P-6 airframe adaptations, was arguably an example of overdevelopment of a basic design, a process of continuous refinement having carried it beyond its apex. Excelling in aesthetic appeal, it was nevertheless a mediocrity as a fighter. Overly stable, the P-6E was a good precision aerobatic aircraft, but it offered slower control response than European contemporaries such as the Hawker Fury, a total of only 45 being built and delivered, as coming to an end in March 1932.

SPECIFICATION: P-6E

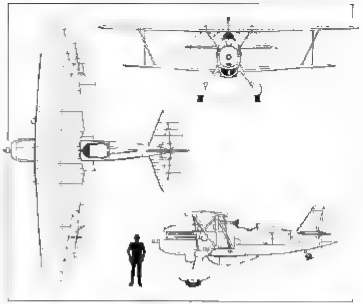
Power Plant: One Curtiss V-1570-23 Conqueror 12-cylinder vee liquid-cooled engine rated at 625 hp at 2 400 rpm for take-off and 600 hp at 5 000 ft (1 525 m). Three-bladed Hamilton Standard ground-adjustable metal propeller. Internal fuel capacity 41·6 Imp gal (189 l) with provision for 4·6 Imp gal (189 l) auxiliary tank.

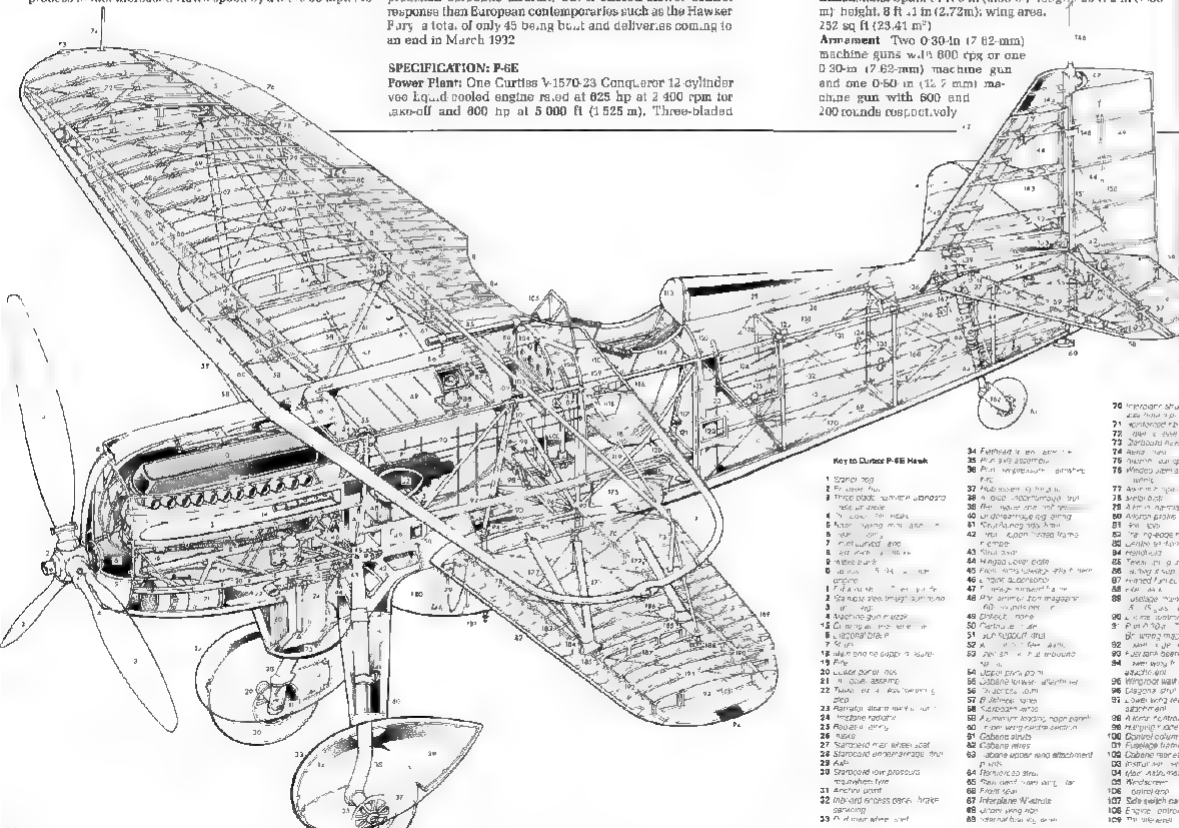
Performance: Max speed, 193 mph (310 km/h) at sea level, 191 mph (307 km/h) at 5,000 ft (1 525 m), 188 mph (302 km/h) at 10,000 ft (3 050 m); econ cruise, 167 m.p.h. (268 km/h); range (internal fuel) 285 m.s (459 km) (with auxiliary tank), 572 m.s (920 km); initial climb 2,460 ft min (12·5 m/sec); time to 5,000 ft (1 525 m), 2·3 min; to 10,000 ft (3 050 m), 5·2 min; service ceiling, 23 900 ft (7 285 m).

Weights: Empty 2,743 lb (1 244 kg); normal loaded 3,436 lb (1 559 kg); max. 3 750 lb (1 701 kg).

Dimensions: Span, 31 ft 6 in (9,60 m); length, 23 ft 2 in (7·06 m); height, 8 ft 11 in (2,72m); wing area, 232 sq ft (23,41 m²).

Armament: Two 0·30-in (7·62-mm) machine guns with 600 rpg or one 0·30-in (7·62-mm) machine gun and one 0·50-in (12·7 mm) machine gun with 500 and 200 rounds respectively.





Key to Curtiss P-6E Hawk

1 Spinner cap
2 Propeller hub
3 Three-blade Hamilton Standard metal propeller
4 Cowling ring
5 Engine bearer
6 Engine mounting bolts
7 Exhaust manifold
8 Exhaust pipe
9 Engine bearer
10 Cylinder block
11 Cylinder head
12 Spark plug
13 Rocker box
14 Rocker box fairing
15 Oil cooler
16 Oil cooler fairing
17 Oil cooler support
18 Water pipe to cooler
19 Pipe
20 Water pump
21 Oil cooler assembly
22 Tube, oil to engine sump
23 Remote stand-by oil tank
24 Inspection cover
25 Propeller clearance
26 Nose
27 Surround metal skin
28 Stainless steel panel
29 Axle
30 Streamlined wheel fairing
31 Anchor point
32 Oleo-type brake, brake operating
33 Oil cooler air duct
34 Fairing
35 Fuel tank assembly
36 Fuel tank support
37 Hub
38 Oleo shock-absorber
39 Axle
40 Undercarriage leg fairing
41 Shock-absorber
42 Undercarriage leg fairing
43 Strut
44 Wheel cover plate
45 Fairing
46 Tube
47 Tube
48 Rear ammunition magazine
49 Bracket
50 Cartridge case
51 Air support strut
52 Air
53 Tube
54 Wheel cover plate
55 Undercarriage
56 Undercarriage
57 Bracket
58 Undercarriage
59 Aluminum decking
60 Lower wing centre-section
61 Cabane struts
62 Cabane wires
63 Cabane wires and attachment points
64 Fairing
65 Rear cockpit
66 Front spar
67 Interplane N-struts
68 Upper wing spar
69 Interplane bracing wires
70 Interplane strut wires
71 Wing root
72 Rear cockpit coaming
73 Cockpit floor
74 Rear
75 Rear
76 Windscreen
77 Windscreen
78 Windscreen
79 Windscreen
80 Windscreen
81 Windscreen
82 Windscreen
83 Windscreen
84 Windscreen
85 Windscreen
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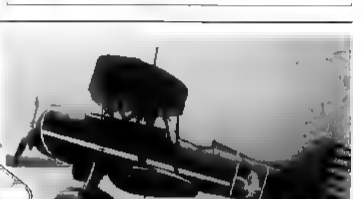
99 Windscreen
100 Windscreen
101 Windscreen
102 Windscreen
103 Windscreen
104 Windscreen
105 Windscreen
106 Windscreen
107 Windscreen
108 Windscreen
109 Windscreen
110 Upper wing trailing-edge
111 Hydraulic control pipe
112 Cockpit floor
113 Heating/ventilation pipe
114 Bias-mounted control cable
115 Rudder bar
116 Rudder
117 Seat support
118 Fuselage
119 Fuselage
120 Fuselage
121 Fuselage
122 Metal
123 Fuselage
124 Baggage compartment
125 Metal
126 Fuselage
127 Seat
128 Fuselage
129 Metal
130 Fuselage
131 Hydraulic control cable
132 Rudder control cable
133 Fuselage structure
134 Fuselage
135 Fuselage
136 Fuselage
137 Fuselage
138 Fuselage
139 Fuselage
140 Fuselage
141 Fuselage
142 Fuselage
143 Fuselage
144 Fuselage
145 Fuselage
146 Fuselage
147 Tail navigation light recess
148 Rudder upper hinge
149 Rudder frame
150 Rudder
151 Rudder post
152 Elevator control horns
153 Upper elevator attachment
154 Elevator control cable
155 Fuselage
156 Fin
157 Fin
158 Fin
159 Fin
160 Tail
161 Fuselage
162 Metal
163 Metal
164 Fuselage
165 Tailplane
166 Tailplane
167 Tailplane
168 Tailplane
169 Tailplane
170 Lower longeron
171 Vertical drainage
172 Metal
173 Metal
174 Lower longeron
175 Vertical tail fin fairing
176 Rear spar
177 Interplane N-struts
178 Upper wing trailing-edge
179 Deep tank filler cap
180 Deep tank A Bilge pump
181 Vent
182 Lower wing aluminum leading-edge panels
183 Front spar
184 Wing structure ribs
185 Rear spar
186 Port navigation light
187 Reinforced rib
188 Aileron actuating linkage
189 Lower wing trailing-edge
190 Rear spar
191 Cabane rib assemblies
192 Front spar
193 Wing structure
194 Rear spar



Above: A P-6E of the 1st Pursuit Group at Selfridge Field, Michigan, during the late 1930s.

P.Z.L. P.11c (September 1931)

The annals of fighter development are punctuated by examples of aircraft that, at the time of their débuts signified major advances in the state of the art. One such was without doubt the P.1, which, designed by Zygmunt Pulawski and built by the Polish State Aircraft Factory in Warsaw, was flown in September 1929. Of all-metal construction with finely corrugated Wibault duralumin skinning, the P.1 established new standards in aerodynamic cleanliness, its most innovative feature being its wing. Pulawski had eliminated the cabane normally featured by high-wing monoplanes, reducing the thickness of the wing centre section and gulling this into the fuselage, simultaneously gaining a substantial reduction in drag and a virtually unobstructed forward field of vision. The wing incorporated slotted ailerons, which also served as landing flaps and was braced at one-third span by pairs of aerofoil section struts.

Progressive development of the basic design resulted within two years in the P.11, which, evolved by way of the configurationally similar but lower-powered P.7, commenced flight testing September 1931, six months after Pulawski's death, and entered production in 1933 as the P.11a, 30 being manufactured for the Polish air arm and these, in fact, being preceded by 50 examples of an export equivalent, the P.11b for Rumania. Meanwhile major redesign of the fighter was being undertaken by Wsiewiod Jakimiuk. The engine thrust line was lowered, the pilot's seat was raised and moved aft, the wing centre section dihedral was increased, the tail assembly was redesigned and armament was doubled. Designated P.11c, this extensively modified fighter entered production in 1934. Licence manufacture was also undertaken in Rumania as the P.11f, and 175 were built for Polish service, deliveries being completed in 1937.

Although barely eight years had elapsed between the début of the P.1 and completion of deliveries of its P.11c derivative, such was the tempo of international fighter development at this time that the Pulawski configuration had already been overtaken, rendering the P.11c obsolescent. When the Wehrmacht assailed Poland began on 1 September 1939, 128 P.11c fighters were included in the Polish Order of Battle, equipping 12 of the 15 squadrons forming the fighter force. Despite the sturdiness and manoeuvrability of the Polish fighter and the skill and determination of its pilots, its performance was inadequate for the effective interception of most Luftwaffe bombers and it was totally outclassed by opposing fighters.

SPECIFICATION: P.11c

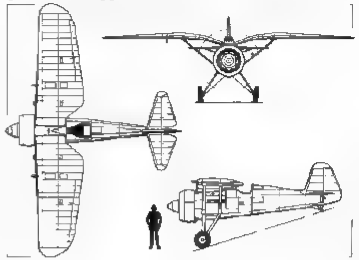
Power Plant: One Skoda-built Bristol Mercury VI S2 nine-cylinder radial, air-cooled engine rated at 620 hp at 2 400 rpm for take-off, 605 hp at 12 500 ft (3 810 m) and 645 hp at 15 500 ft (4 725 m). Two-bladed fixed-pitch wooden Szomanski propeller. Fuel capacity, 71 Imp gal (323 l).

Performance. Max speed, 186 mph (300 km/h) at sea level, 242 mph (390 km/h) at 16,045 ft (5,500 m); range at econ cruise, 435 mls (700 km); time to 16,405 ft (5 000 m), 6·0 min, to 22,965 ft (7 000 m), 13·0 min; service ceiling, 26,245 ft (8 000 m).

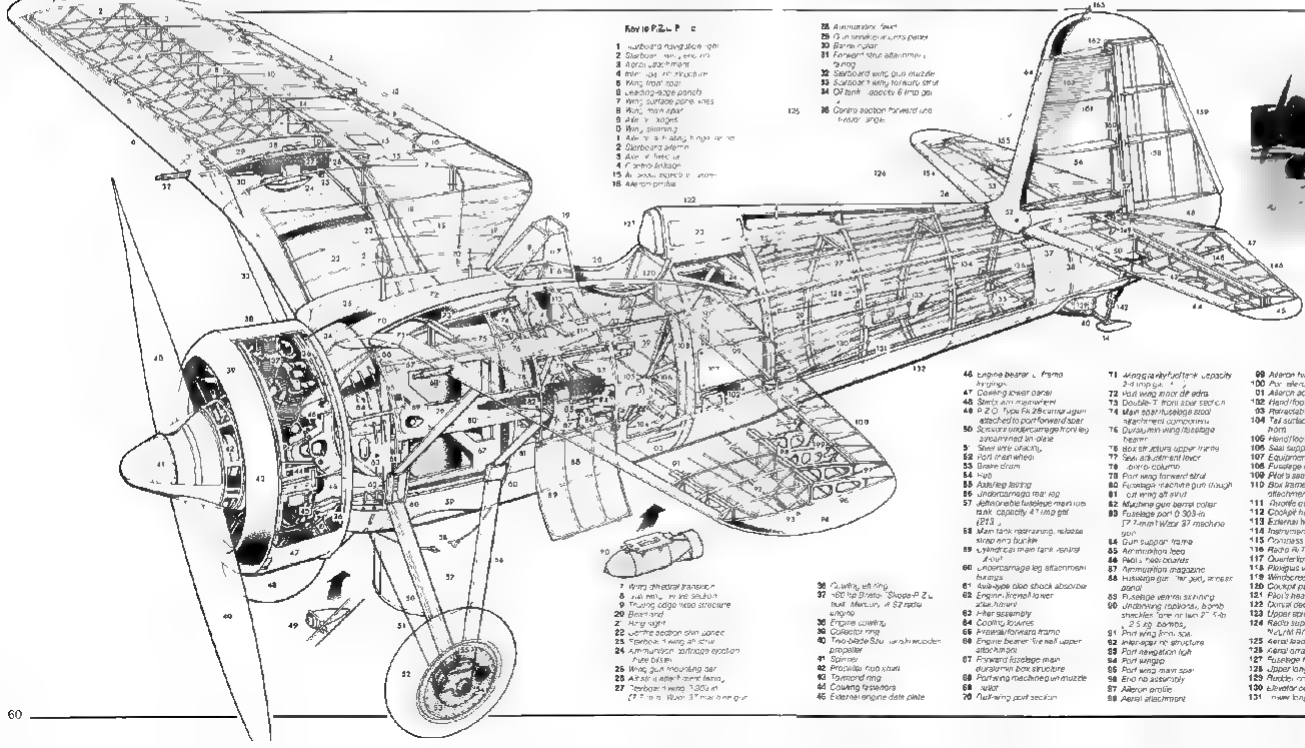
Weights: Empty equipped, 2 529 lb (1 147 kg); normal loaded, 3,593 lb (1 630 kg).

Dimensions. Span, 35 ft 2 in (10·72 m); length, 24 ft 9¼ in (7·55 m); height, 9 ft 4¼ in (2·85 m); wing area, 192·7 sq ft.

Armament. Two 7,7-mm KM Wz 33 machine guns with 500 rpg and (some aircraft) two wing-mounted Wz 33 machine guns with 300 rpg.



Above: A P.11c fighter of the 112 Squadron of the 4th Air Regiment (Legeda) at Warsaw-Okecie airfield. At the time of the German attack, this squadron had six P.11c fighters, of which only one had four guns and four P.11a fighters.



Boeing P-26 (March 1932)

Above: All [illegible] photographs show the March [illegible] with bomb racks for [illegible] from Wheeler Field in Hawaii.

At the beginning of the thirties, the biplane had been firmly entrenched as principal among fighter configurations since WWI, and the advent of the all metal semi monocoque low wing monoplane was seen as little more than an aberration from the mainstream of fighter development. The Boeing fighter flown on 20 March 1932 and designed under the leadership of G N Monteith, was one such

When adopted by the US Army it was acclaimed as radical, barely three years later it was viewed as obsolescent. With anachronistic multiplicity of bracing wires open cockpit and fixed undercarriage adopted to render palatable to the traditionalists the more advanced aspects of the fighter, the Boeing fighter was to be seen to represent no more than a brief inter-war transitional stage

A private venture of which the three company-funded prototypes were eventually procured by the US Army as XP-26s (later YIP-26s) on 15 June 1932, the Boeing fighter was ordered into production as the P-26A, entering service in 1934. The US Army procured 136, two of which were completed with fuel injection engines as P-26Bs and 23 with provision for such engines as P-26Cs. Unofficially dubbed Peashooter, it was sturdy, responsive and manoeuvrable; less attractive foibles were an overly abrupt stall and a side-to-side rocking motion at speed on the ground.

SPECIFICATION P-26A

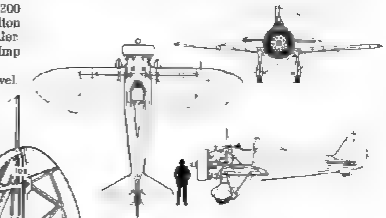
Power Plant: One Pratt & Whitney R-1340-27 Wasp nine-cylinder radial air-cooled engine rated at 600 hp at 2 200 rpm for take-off and 570 hp at 7 500 ft (2 285 m). Hamilton Standard ground-adjustable metal two-bladed propeller. Internal fuel capacity, 89 Imp gal (405 l), including 43 Imp gal (195 l) in two auxiliary wing tanks

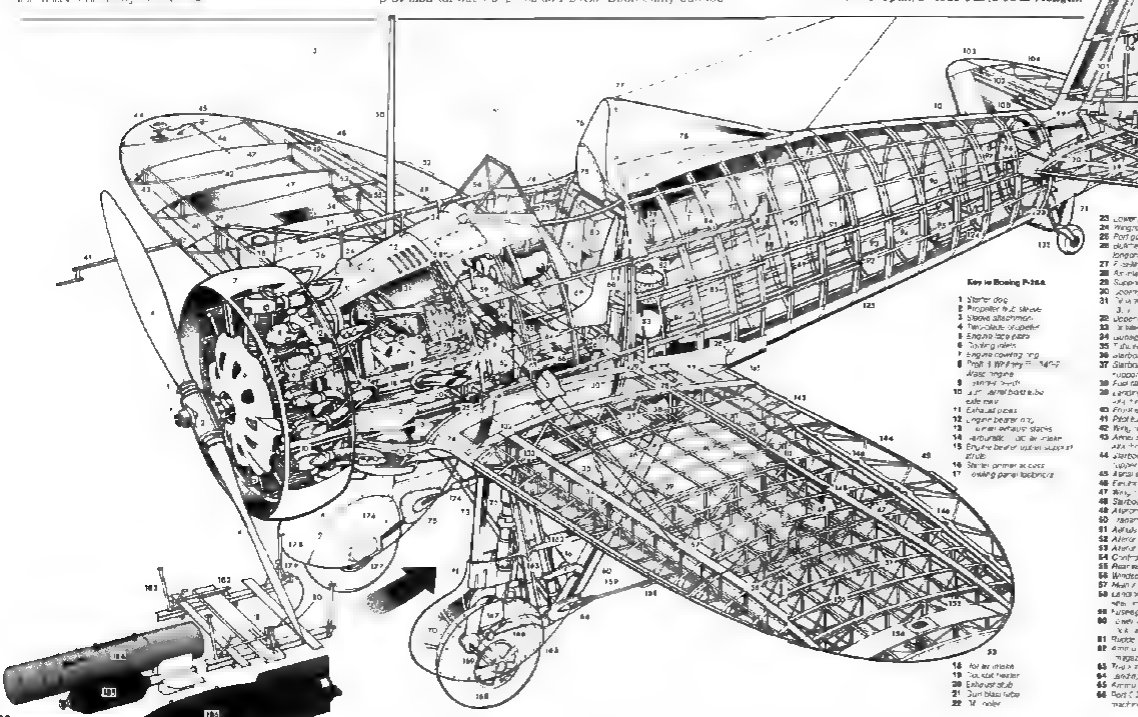
Performance: Max speed, 211 mph (339 km/h) at sea level, 226 mph (364 km/h) at 15,000 ft (4 570 m), max continuous cruise, 189 mph (320 km/h) at 7,500 ft (2 285 m), range (max internal fuel, 570 m/s (917 km) at max cruise; initial climb, 2,360 ft/min (11,99 m/sec); time to 7 500 ft (2 285 m), 3 65 min, to 15,000 ft (4 570 m), 8·0 min, service ceiling, 27 400 ft (8 350 m)

Weights Empty, 2 271 lb (1 030 kg), normal loaded, 3 012 lb (1 366 kg), max, 3,360 lb (1 524 kg

Dimensions: Span, 27 ft 11⅝ in (8·52 m), length, 23 ft 7¼ in (7,18 m); height (tail down), 10 ft 5 in (3,17 m); wing area, 148·5 sq ft (13,68 m²).

Armament: Two 0 30-in (7 62-mm) Browning M-2 machine guns with 500 rpg (optional, starboard alternative of 0 50-in, 12, 7-mm M-1921 machine gun with 200 rounds).

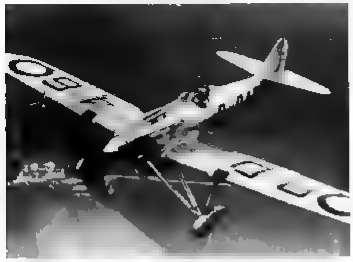




Key to Boeing P-26A

1 Starter dog
2 Propeller hub, blade
3 Blade attachment
4 Two-blade propeller
5 Engine face plate
6 Cooling gills
7 Engine cowling ring
8 Pratt & Whitney R-1340-27 Wasp engine
9 Starter motor
10 Air-cooled cast iron cylinder
11 Exhaust pipes
12 Exhaust collector ring
13 Lower exhaust stacks
14 Exhaust ejector
15 Engine bearer support struts
16 Starter gearbox cover
17 Cowling panel fastenings
18 Air intake
19 Oil cooler housing
20 Exhaust stub
21 Oil filler tube
22 Oil cooler
23 Lower panel access
24 Firing gear
25 Port gun barrel
26 Gun-mount lower longeron attachment
27 Fuselage forward frame
28 Air intake stiffener uprights
29 Support strut attachment points
30 Cooling louvres
31 Wing root fairing (Type 3)
32 Upper fairing
33 Fairing screws
34 Wing root tube supports
35 Tubular gun sight
36 Starboard wing fuel tank
37 Starboard landing strut support strut and brace
38 Fuel filler cap
39 Landing wires, outboard side rear
40 Exhaust pipe
41 Pitot tube
42 Wing, underfuselage
43 Aileron control cable
44 Starboard navigation lights, upper and lower surfaces
45 Aerial lead in
46 Fin fairing
47 Wing, centre section
48 Starboard aileron
49 Aileron hinge points
50 Aerial mast, rear mast
51 Aerial
52 Aileron tab
53 Aileron control linkage
54 Control rods
55 Rear landing wire
56 Windscreen panel
57 Main fuselage longeron
58 Longitudinal metal underskin, main skin
59 Fuselage upper longeron
60 Cockpit longeron, upper rear
61 Rudder, central assembly
62 Rudder, central assembly, hinge points, and right side fin
63 Trim tabs
64 Jettisoning wires bracket
65 Aerial lead in
66 Port 0 30-in (7 62-mm) machine gun
67 Instrument panel shelf
68 Seat support frame
69 Fairing panel
70 Throttle quadrant
71 Map and document case
72 Hinged entry flap
73 Equipment pouch
74 Seat cushion
75 Pilot's headrest
76 Harness fastening
77 Rear-view mirror
78 Hull over structure
79 Windscreen frames
80 Wide-head rubber rear windscreen frames
81 Fuselage frame frame
82 Access panel
83 Hinged hydraulic access cover
84 Hoisting hair
85 Tail wheel, [illegible]
86 Rear-view mirror mounting
87 Aft-mounted equipment shelf
88 Fuselage frames
89 Rudder, [illegible] lights, upper and lower surfaces
90 Elevator control cables
91 Elevator tab, [illegible]
92 Adjustable tailplane brackets
93 Tailplane control cables
94 Fin buckle
95 Rear fuselage structure
96 Tailplane control linkage
97 Elevator control [illegible]
98 Fuselage, [illegible] frame, bottom support
99 Tail wheel
100 Starboard elevator hinge
101 Starboard tailplane
102 Tailplane spar
103 Elevator outer hinge
104 Starboard elevator
105 Fin frame spar
106 Tailplane [illegible]
107 Fin structure
108 Rudder upper hinge
109 Rudder aerial mast
110 Rudder inner frame
111 Rudder hinge
112 Elevator torque tube
113 Rudder post
114 Rudder control horns
115 Elevator
116 Port elevator
117 Fairing hinge
118 Tailplane structure
119 Elevator [illegible] hinge
120 Aligning rich lower fuselage attachment
121 Aileron fairing
122 Aileron
123 Aileron leg
124 Aileron control rods
125 Fuselage fairing
126 Wingroot fairing
127 Aileron control rod assembly
128 Rear spar fairing attachment
129 Fuselage angled main frame attachment
130 Fuselage main fuel tank
131 Fuel filler cap
132 Front spar stub wing attachment
133 Mainwheel leg attachment
134 Front spar
135 Landing wires support strut and plate
136 Undercarriage [illegible] rear member
137 Stub wing structure
138 [illegible] main spar attachment
139 Fuel filler cap
140 Port wing fuel tank
141 Rear spar
142 Transmitter aerial
143 Wearing ring rings
144 Port aileron
145 Aileron tab
146 Aileron hinges
147 Aileron control linkages
148 Rear landing wire anchorage
149 Aileron control rods
150 Wing main rib stations
151 Inboard rib stations
152 Tail support strut, [illegible]
153 Port wing tip
154 Port navigation lights, upper and lower surfaces
155 Wing structure
156 Port aileron pivot
157 Landing wires, [illegible]
158 Wing strut bracket
159 Inboard flying wires
160 Undercarriage bracket frame
161 Brake cable assembly
162 Tube brake [illegible]
163 [illegible] mounting
164 Flying wires attachment fitting
165 Wheel spat
166 Chocks
167 Brake arm
168 Port main wheel
169 Axle
170 Spat inner frame
171 Spat leg [illegible]
172 Mainwheel [illegible]
173 Inboard flying wires
174 Jettisonable [illegible]
175 Starboard inner fairing attachment
176 Spat panel
177 Wheel mounting
178 Inter-fuselage horizontal [illegible] [illegible]
179 Arming handle
180 Bunt [illegible] [illegible] cover
181 Individual [illegible] [illegible]
182 Support frame
183 Formed [illegible] brackets
184 Possible [illegible] [illegible] 94 165
185 Not (12 6 kg) practice bombs [illegible]
186 [illegible] (45 kg) bombs [illegible]

Dewoitine D 500-510 (June 1932)



Above: The first production [illegible] the prototype D 500 [illegible] 1932. [illegible] Note the [illegible] flush-riveted metal skin [illegible] further differentiating it visually, resulting in some confusion of mass production.

Technical innovations initiated spontaneously and independently in two or more countries simultaneously are by no means unknown in aviation history, and the all-metal semi-monocoque low-wing fighter monoplane provides but one example. Such warplanes were evolving over a broadly parallel timescale in both France and the USA, but that conceived in the former country by Emile Dewoitine as the D 500 was, from certain aspects, the more advanced and was to place the French aircraft industry temporarily in the vanguard of international fighter development.

The American fighter, the P-26 (see page 62-63), was conceptually similar to the D 500 but antithetic in detail—the one portly and curvaceous and the other angularly rakish—and more conservative. Dewoitine was uncompromising in his effort to achieve the greatest practicable advance in the state of the art, whereas the Boeing team made concessions to the traditionalists. Both fighters employed flush-riveted metal-skinned semi-monocoque structures, but whereas the two-spar wing of the P-26 was braced by lift and drag wires, the single-spar wing of the D 500 was cantilevered and this feature represented a more radical step forward in the evolution of fighter design.

Although conceived a year earlier than the Boeing fighter, the D 500 did not fly until three months later, on 18 June 1932. More stable than the fighters then serving the Armée de l'Air, it was, nevertheless, very manoeuvrable and well behaved under most circumstances. Like its Boeing contemporary it was to be criticised on the score of its high approach and landing speeds; it was also demanding in stick force for recovery from a spin due to a tendency towards control reversal, resulting from elevator upload after spin entry.

The D 500 was committed to production on 23 November 1933, 300 being supplied to the Armée de l'Air, which also received 133 cannon-armed D 501s. Availability of the more powerful HS 12 Ycrs prompted replacement of the 690 hp HS 12 Xbrs in a D 500 airframe, this combination flying in August 1934 as the prototype D 510. Essentially similar to the D 501, apart from increased fuel capacity and modified undercarriage, the D 510 entered service with the Armée de l'Air mid-1935, the service receiving 88 of the 118 D 510s subsequently built.

SPECIFICATION: D 510

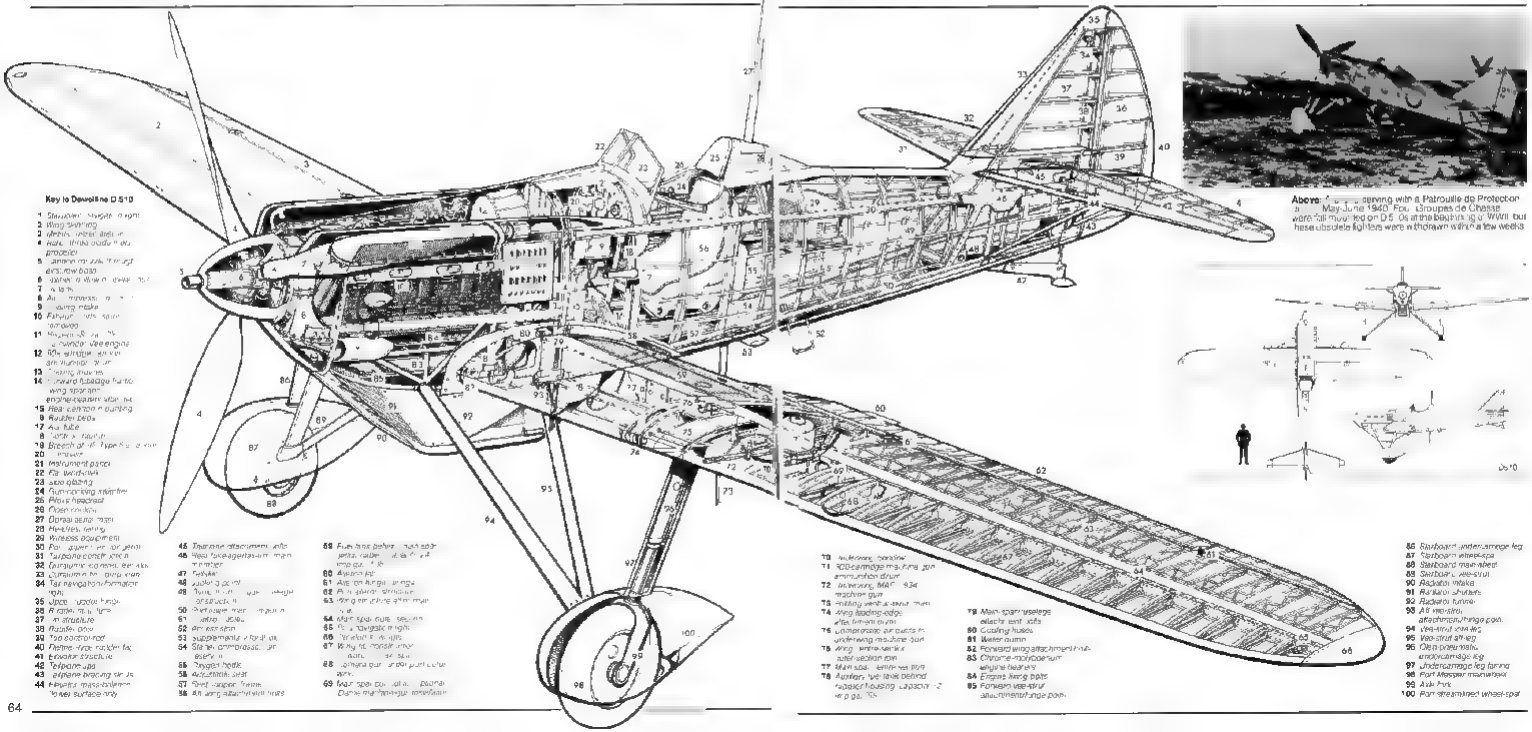
Power Plant: One Hispano-Suiza 12 Ycrs 12-cylinder liquid-cooled vee engine rated at 760 hp at 2,400 rpm for take-off and 860 hp at 10,830 ft (3 300 m). Ratier 1239 ground-adjustable metal three-bladed propeller. Internal fuel capacity 76 Imp gal (345 l).

Performance: Max speed 205 mph (330 km/h) at sea level, 212 mph (341 km/h) at 3,280 ft (1 000 m), 230 mph (369 km/h) at 9,840 ft (3 000 m), 250 mph (402 km/h) at 16,405 ft (5 000 m); econ cruise, 199 mph (320 km/h) at 13,125 ft (4 000 m); range 435 miles (700 km); climb to 3 280 ft (1 000 m) 1 32 min, to 9 840 ft (3 000 m), 3 6 min, to 16,405 ft (5 000 m), 5 95 min; service ceiling 34 450 ft (10 500 m).

Weights: Empty equipped 3,142 lb (1 425 kg), normal loaded, 4,253 lb (1 929 kg).

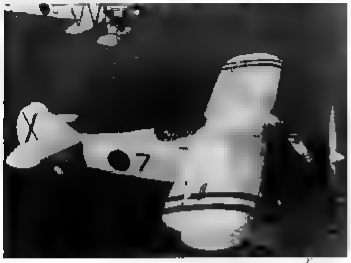
Dimensions: Span, 36 ft 8 in (12,09 m); length, 26 ft 0¾ in (7,94 m); height, 7 ft 11¼ in (2 42 m); wing area, 377 6 sq ft (35 50 m²).

Armament: One 20-mm Hispano-Suiza S9 (Oerlikon) cannon with 60 rounds and two 7.5 mm MAC modèle 34 machine guns with 300 rpg.



Above: [illegible] serving with a Patrouille de Protection [illegible] May-June 1940. Four Groupes de Chasse were still nominally equipped with D 510s, but these obsolete fighters were withdrawn within a few weeks.

Fiat CR.32 (April 1933)



Above: [illegible] during Spanish [illegible]

The synthesis of a decade of continuous fighter evolution its genus dating to 1923 and the debut of the CR 1, the CR.32 was a thoroughbred with a distinguished pedigree. Indisputably one of the truly outstanding fighters of the mid thirties, its success was in no small part responsible for the reluctance of the Regia Aeronautica to relinquish the biplane configuration for fighters and persistence in development of such long after they had become outmoded.

Of fabric-covered light alloy and steel construction and utilising the distinctive rigid interplane struting arranged in the form of Warren trusses and inherited from the S.V.A. fighter of 1917, the Fiat CR.32 offered superlative manoeuvrability and extremely good diving characteristics. It excelled in the close-in, tight-manoeuvring, high-g style of combat, being a dogfighter par excellence, and when opposed by fighters armed with rifle-calibre machine guns, the longer-ranging 12.7 mm weapons of the CR.32 endowed the little biplane with an advantage. Perhaps its most outstanding virtue was its remarkable robustness, enabling it to withstand the roughest usage and absorb a high degree of battle damage yet remain airborne.

The CR.32 was first flown on 28 April 1933, and the initial batch of 24, was exported to China where it made its combat debut, production of 282 of the initial model following between March 1934 and February 1936 for the Regia Aeronautica. A further 283 with two- replaced by four-gun armament were built as the CR.32bis for the Italian service, similar fighters being exported to Austria (45) and Hungary (52). The CR.32ter of which 150 were built reverted to twin-gun armament, but the fighter was badly afflicted with obsolescence by January 1938, when the definitive version, the CR.32quater entered production. Nevertheless, 337 were built for the Regia Aeronautica, plus five for Paraguay and nine for Venezuela, before production ended in May 1939, a total of 1,211 having been built to which were to be added 100 licence-built (1940-43) in Spain.

The CR.32 was a thoroughly proven warplane when committed to combat over Spain from August 1936 as the vanguard of the Italian Aviación de Tercio, 375 being sent of which 127 were flown by Spanish Nationalists and participated in every campaign of the conflict.

SPECIFICATION CR.32bis

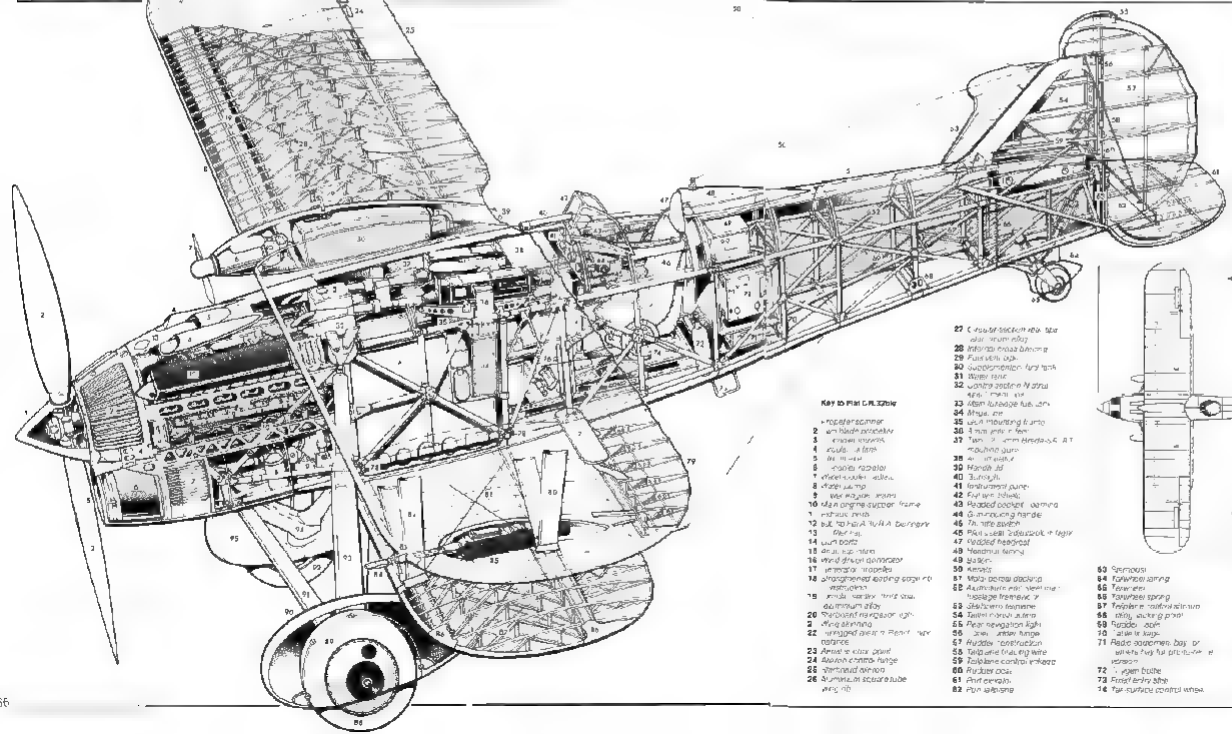
Power Plant: One Fiat RA 30 R.A bis 12-cylinder vee liquid cooled engine rated at 800 hp at 2,900 rpm for take-off (for three minutes) and 600 hp at 9,840 ft (3 000 m). Two-bladed Fiat ground adjustable metal propeller. Internal fuel capacity, 77 Imp gal (350 l) including 5.5 Imp gal (25 l) supplementary upper wing tank.

Performance: Max speed 205 mph (330 km/h) at sea level, 217 mph (350 km/h) at 9 840 ft (3 000 m), 204 mph (329 km/h) at 16 405 ft (5 000 m); range, 485 mls (780 km) at 195 mph (314 km/h) at 15,750 ft (4 800 m); time to 3,280 ft (1 000 m), 1 46 min, to 9 840 ft (3 000 m), 5 5 min, to 16,405 ft (5 000 m), 11 43 min, service ceiling, 26,245 ft (8 000 m).

Weights: Empty equipped, 3,086 lb (1 400 kg), normal loaded 4 343 lb (1 970 kg).

Dimensions: Span 31 ft 1½ in (9 50 m), length 24 ft 5½ in (7,45 m), height, 8 ft 7½ in (2 63 m), wing area, 237·89 sq ft (22 10 m²).

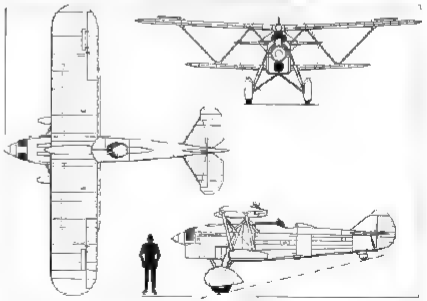
Armament: Two 12 7 mm Breda SAFAT machine guns with 350 rounds for each gun and two 7,7 mm Breda SAFAT machine guns.



Key to Fiat CR.32bis

1 Propeller spinner
2 [illegible] blade propeller
3 Engine cowling
4 Cowling [illegible]
5 [illegible]
6 Engine [illegible]
7 Wheel cover [illegible]
8 Water pump
9 Water [illegible]
10 Main engine support frame
11 Exhaust pipes
12 Bolt to hold RA.A bearing
13 Oil tank
14 Lug bolts
15 [illegible]
16 Wood shaft connector
17 Generator [illegible]
18 Strengthened leading edge rib stiffeners
19 Small leading edge strut, aluminium alloy
20 Stringed fuselage light
21 Wing stringer
22 Wrapped seam Rapid [illegible] fabrics
23 Aileron cross panel
24 Aileron control hinge
25 Stressed skin
26 Stringer or square tube [illegible]
27 Circular section [illegible] stringer alloy
28 Internal cross bracing
29 Fuel [illegible]
30 Supplementary fuel tank
31 Oil tank
32 Central section fuel [illegible]
33 Main fuselage fuel tank
34 Mounting
35 Gun mounting [illegible]
36 [illegible]
37 Twin [illegible] Breda SAFAT machine guns
38 [illegible]
39 Handle bar
40 Turnbuckle
41 Instrument panel
42 Foot rest [illegible]
43 Padded headrest [illegible]
44 Gun firing handle
45 Tail fairing
46 Pilot seat [illegible]
47 Padded headrest
48 Headrest fairing
49 Stabiliser
50 Fairing
51 Main panel stiffener
52 Aluminium alloy [illegible] baggage [illegible]
53 Stabiliser fairing
54 Tailplane [illegible]
55 Rear navigation light
56 [illegible] hinge
57 Rudder construction
58 Tailplane fairing wire
59 Tailplane control [illegible]
60 Rudder [illegible]
61 Port navigation light
62 Port aileron
63 Spar boss
64 Tailwheel spring
65 Tailwheel
66 Tailwheel spring
67 Outrigger [illegible] trench-type balance
68 Tailplane [illegible] aluminium
69 Alloy [illegible] pivot
70 Rudder [illegible]
71 Radio equipment bay [illegible] [illegible]
72 [illegible] tube
73 Fixed entry step
74 Tail surface control wires
75 [illegible]
76 Rudder pedal
77 Outrigger [illegible] trench-type balance
78 Fuselage [illegible] mainplane attachment joints
79 Aileron [illegible]
80 Rear Warren-type interplane struts (fuselage)
81 Valve [illegible]
82 Forward Warren-type mainplane struts (fuselage)
83 Port navigation light
84 Gun muzzle
85 Port [illegible] mounted above [illegible] panel
86 Wing strengthening plates
87 [illegible] fairing
88 Port mainplane
89 Removable [illegible] section
90 Wire [illegible]
91 Mainwheel leg
92 Starboard mainplane
93 Metal [illegible] strut
94 Mainplane [illegible] attachment
95 Starboard strut

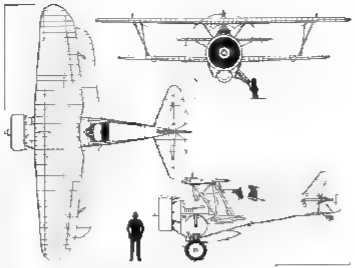
Above: No. 34 Squadriglia was the [illegible] production model [illegible]



Curtiss Model 68 Hawk III (May 1933)

By the mid-thirties, the world's major air forces had, with but two or three noteworthy exceptions, accepted as inevitable the imminent demise of the biplane as a standard fighter configuration. Smaller air arms, conversely, were reluctant to embrace the less tractable and forgiving fighter monoplane, with the demands that it imposed in exchange for advanced speed and climb capabilities. An export market thus remained for high-performance fighter biplanes and pre-eminent in this field was the Hawk III, the synthesis of a decade of Hawk evolution with retractable main undercarriage members as a concession to modernity.

The appellation of Hawk had become effectively a generic name for the many single-seat fighting biplanes evolved from the basic design by William B. Gilmore and George Page, and what was to be considered a second generation in the Hawk series stemmed from the Hawk II demonstrator which, flown early in 1932, had been purchased by the US Navy as the XF11C-2. Twenty-eight production examples had been ordered as F11C-2s, the fourth being completed with manually-retractable main undercarriage members and flown in May 1933 as the XF11C-3. Meanwhile, a second prototype in which metal supplanted the traditional Hawk wooden wing structure had been ordered as the XF11C-1.



The undercarriage system of the XF11C-3 and the metal wing of the XF11C-1 had then been combined with a raised aft turtle deck and a partial cockpit canopy to produce the BF2C-1. The delivery of 27 examples to the US Navy had begun on 7 October 1934, but it had soon been discovered that, at cruising rpm, the Cyclone engine set up a potentially disastrous sympathetic vibration with the metal wing structure, the problem proving insoluble and the BF2C-1s being hurriedly withdrawn from service.

Curtiss, reluctant to write off the development and anxious to offer an improved Hawk on the export market in which the Hawk II, equivalent of the F11C-2, had enjoyed much success, reverted to the wooden wing structure of the XF11C-3 and offered the retractable-gear fighter as the Hawk III. During 1935-38, 138 Hawk IIIs were exported, 102 of these to China (where 90 were assembled from kits), and with delivery of the last in June 1938 production of a truly classic fighter series came to an end.

SPECIFICATION: Hawk III

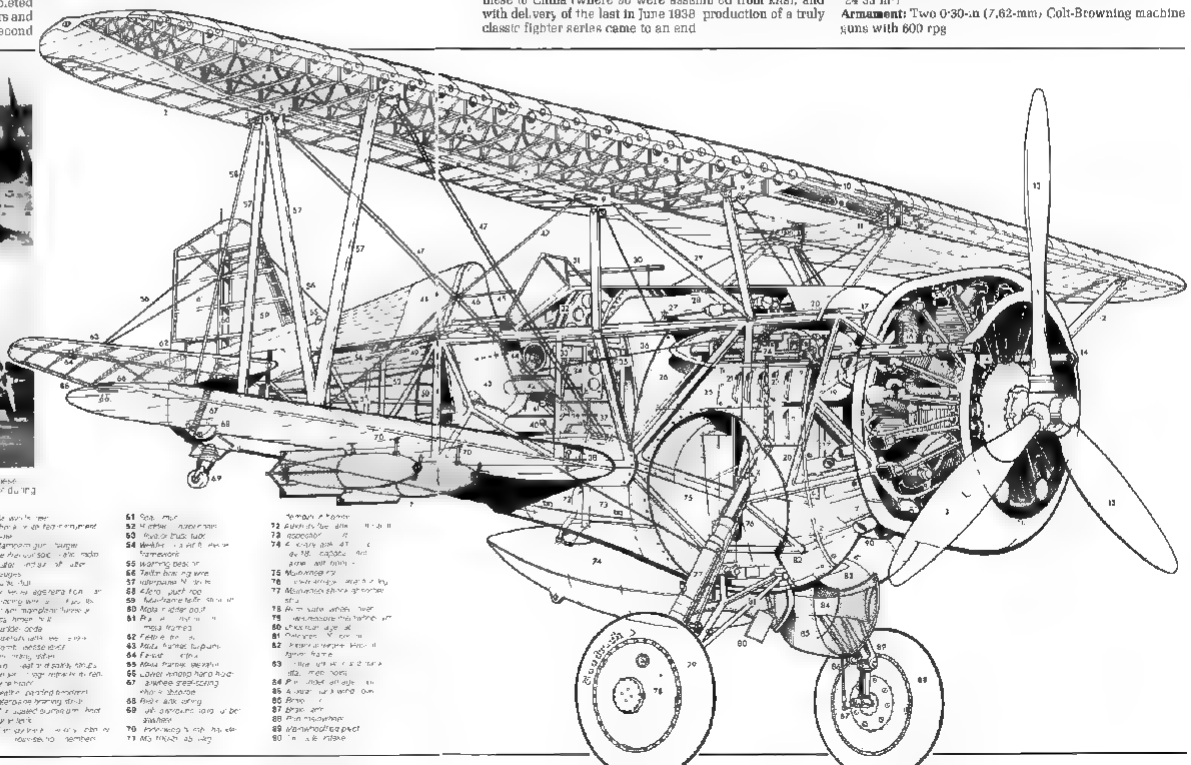
Power Plant: One Wright SR-1820-F53 Cyclone nine-cylinder radial air-cooled engine rated at 785 hp at 2,200 rpm for take-off and 745 hp at 9,600 ft (2,925 m). Three-bladed ground adjustable Hamilton Standard metal propeller. Internal fuel capacity, 62 Imp gal (418 l) with provision for 41.6 Imp gal (209 l) auxiliary tank.

Performance: Max speed, 202 mph (325 km/h) at sea level, 240 mph (387 km/h) at 11,500 ft (3,505 m); normal cruise, 204 mph (328 km/h) at 11,500 ft (3,505 m); range (internal fuel), 575 mls (925 km), (with auxiliary tank, 780 mls (1,270 km). Initial climb, 2,200 ft/min (11.16 m/sec), time to 5,000 ft (1,525 m), 2.4 min; service ceiling, 25,800 ft (7,865 m).

Weights: Empty equipped, 3,213 lb (1,457 kg); normal loaded, 4,317 lb (1,958 kg); max, 4,645 lb (2,107 kg).

Dimensions: Span, 31 ft 5 in (9.58 m); length, 23 ft 5 in (7.14 m); height, 9 ft 9½ in (2.98 m); wing area, 262 sq ft (24.33 m²).

Armament: Two 0·30-in (7,62-mm) Colt-Browning machine guns with 600 rpg.



Above: Hawk IIIs of the Air [illegible] provided the backbone of the [illegible] during 23-38.

Key to Curtiss Hawk III

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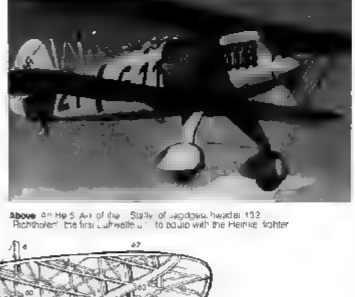
Heinkel He 51 (Summer 1933)

Noteworthy in that it symbolised the renaissance of German military aviation rather than for any originality of concept or intrinsic capability, the He 51 was the warplane on which the Luftwaffe fighter element metaphorically cut its teeth. The first German aircraft to fire its guns in anger since WWI, the He 51 was a sturdy, thoroughly orthodox fighter displaying something of the elegance of line that the Günter brothers, Walter and Siegfried, were to make the indelible hallmark of mid to late thirties Heinkel aircraft. The He 51 was mettlesome and did not suffer fools gladly. Forward visibility in the three-point attitude was totally obscured and comparatively high training attrition resulted from an inclination to bounce on landing.

A progressive development of the experimental He 49, the He 51 was the first post WWI German fighter to be built in large numbers. An initial series of 150 was divided between Heinkel and Arado, with the first production He 51A-1 leaving the former's line in April 1935. Production switched to the minimally-modified He 51B-1 with twin-wire undercarriage bracing and shackles for an auxiliary tank contracts being placed for a further 150 from Arado and 200 from Erla, with, as a direct result of the Spanish Civil War, yet 200 more being ordered from Fieseler.

The He 51 first saw combat over Spain in the late summer of 1936, flown by the so-called Jagdstaffe Eberhard which was to provide the nucleus of the Legion Condor. By late 1938, it was tacitly admitted that the He 51 was inferior in all respects to the opposing I-15 in the classic close in, high-g manoeuvring style of combat. It thus relinquished the air-air role from the late spring of 1937. Those He 51s retained by the Legion being assigned the close air support mission, but most being transferred to the Spanish Nationalists for similar tasks. The final 100 Fieseler-built aircraft were intended primarily for Spanish close air support units or Grupos de Cadena, and were fitted from the outset with racks for six 22-lb (10-kg) bombs as He 51Cs. Production was completed mid-1937, and a total of 135 He 51s was shipped to Spain. Forty-six completed as He 51B-2 twin-float fighters, but, as a type, the Heinkel biplane enjoyed a comparatively short first line operational life, being relegated to the Jagdfliegerschulen in 1938.



Above An He 51 A-1 of the Staffel of Jagdgeschwader 132 'Richthofen' the first Luftwaffe unit to equip with the Heinkel fighter

SPECIFICATION. He 51B-1

Power Plant: One BMW VI 7,3Z 12-cylinder vee liquid-cooled engine rated at 750 hp at 1,700 rpm for take-off and having a normal rating of 550 hp at 1,530 rpm. Fixed-pitch two-bladed Schwarz wooden propeller. Internal fuel capacity 46 Imp gal (210 l).

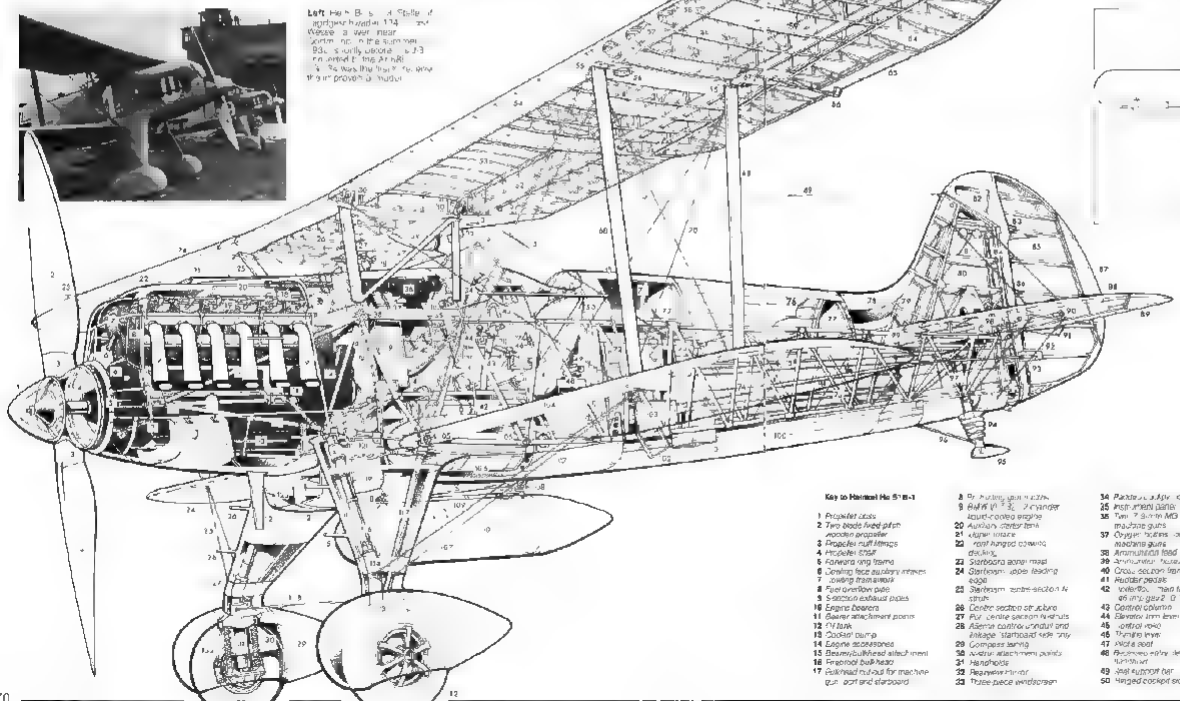
Performance: Max speed, 205 mph (330 km/h) at sea level, 193 mph (310 km/h) at 13,125 ft (4 000 m), range (85% max continuous power), 242 mls (390 km) at 174 mph (280 km/h) at sea level, 345 mls (570 km) at 162 mph (260 km/h) at 13 125 ft (4 000 m), 435 mls (700 km) at 137 mph (220 km/h) at 19,685 ft (6 000 m); time to 3,280 ft (1 000 m), 1 4 min to 6 560 ft (2 000 m), 3·1 min; service ceiling, 25 260 ft (7 700 m).

Weights: Empty 3,247 lb (1 473 kg), normal loaded, 4,189 lb (1 900 kg).

Dimensions: Span 36 ft 1 in (11 00 m), length, 27 ft 8¼ in (8,40 m), height, 10 ft 6 in (3,20 m), wing area, 292 78 sq ft (27 20 m²).

Armament Two synchronised 7,9-mm MG 17 machine guns in forward fuselage with 500 rpg.

Left Heinkel He 51 B-1 of the Staffel of Jagdgeschwader 134 'Grosdeutschland' based at Werneuchen, near Berlin, in autumn 1936. Although the type was the last of the biplane fighters, it was the first to show marked improvement over its predecessors



Key to Heinkel He 51 B-1

1 Propeller boss
2 Two blade fixed pitch wooden propeller
3 Propeller cuff fittings
4 Propeller cowl
5 Forward ring frame
6 Cowling face auxiliary intakes
7 Cowling transverse
8 Fuel overflow pipe
9 5-section exhaust pipes
10 Engine bearers
11 Bearer attachment points
12 Oil tank
13 Cooler clamp
14 Engine accessories
15 Beam-bulkhead attachment
16 Firewall bulkhead
17 Bulkhead cut-out for machine gun port and starboard
18 Port fuselage upper longeron
19 Bulkhead
20 Fuselage frame
21 Upper longeron
22 Roof hinged opening decking
23 Starboard longeron
24 Starboard upper leading edge
25 Starboard centre-section fairing
26 Centre section structure
27 Port centre section fairing
28 Aileron control cable and linkage, starboard side only
29 Compass fairing
30 Aileron attachment points
31 Handholds
32 Rear view mirror
33 Three-piece windscreen
34 Radiator fairing
35 Instrument panel, 'Telefunken'
36 Twin 7,9-mm MG 17 machine guns
37 Oxygen bottles, between machine guns
38 Ammunition feed
39 Ammunition chute, 500 rpg
40 Cross section framework
41 Rudder pedals
42 Underfuselage fuel tank, 46 Imp gal (210 l)
43 Control column
44 Elevator trim lever
45 Control cable
46 Rudder trim lever
47 Hinged seat
48 Rudder hinge, lower
49 Hinged cockpit side bar
50 Tailplane
51 Interplane struts-bracing
52 Upper wing main spar
53 Upper wing panel, 3-section
54 Plywood leading edge skin
55 Interplane strut upper attachment points
56 Adjustable strut
57 Leading edge framework
58 Upper wing front spar
59 Upper wing rear intermediate
60 Lattice ribs
61 Port aileron
62 Port tailplane
63 Rear tailplane
64 Aileron hinge
65 Fixed tailplane
66 Tail hinge
67 Tailplane bracing
68 Interplane struts
69 Wireless aerial
70 Interplane strut drawing
71 Baggage compartment
72 Rear equipment
73 Welded steel tube fuselage framework
74 Rudder control
75 Elevator control lines
76 Fairing, longeron
77 Duralumin wood stringer framework
78 Fuselage/tailplane fairing
79 Main leading edge frame
80 Tailplane structure
81 Tailplane bracing wires (upper)
82 Rudder balance
83 Rudder upper hinge
84 Rudder post
85 Rudder structure
86 Rudder, centre hinge
87 Rudder fin
88 Fin framework
89 Elevator balance
90 Elevator hinge pin
91 Elevator arc hinge
92 Tailplane bracing wires (lower)
93 Rudder hinge, bottom
94 Leaver cut
95 Tailskid
96 Tailskid supporting spring
97 Tailskid shock absorber leg
98 Elevator control fairing
99 Chord-wise ribs through tailplane
100 Fabric covering, elevator
101 Rudder
102 Entry step
103 Radio equipment
104 Port lower wing leading edge
105 Lower wing/undercarriage attachment points
106 Port lower access cover plate removed
107 Lower wing panel
108 Auxiliary tank rear shackles
109 Fuel line
110 Jettisonable auxiliary tank
111 Wing panel
112 Port main wheel
113 Vertical leg socket
114 Chromium-plated hydraulic hose
115 Inspection/maintenance footholds
116 Main wheel leg
117 Leg socket fitting
118 Auxiliary tank forward shackles
119 Radiator
120 Undercarriage fairing fuselage attachment plate
121 Ventral radiator cowl
122 Airflow vane
123 Controllable shutter
124 Starboard lower wing skinning
125 Lower bracing wires
126 Inspection/maintenance footsteps
127 Twin undercarriage legs
128 Twin-wire undercarriage bracing
129 Starboard main wheel fairing
130 Springs
131 Hydraulic shock absorber dampers
132 Lubricant lead
133 Starboard main wheel

Avia B.534 (August 1933)

When in the second half of 1935 the B.534 began to enter the active inventory of the Czechoslovak air arm, it was widely acclaimed the finest fighting biplane in Continental Europe. Aerodynamically refined, with well-balanced contours and a finely cowled engine, it established new standards in performance. Yet within two years, it was to provide the unwitting means of demonstrating that the fighter biplane was manifestly passé. The venue for the demonstration was the 4th International Flying Meeting held at Zürich-Dübendorf between 23 July and 1 August 1937 where the B.534, the most-favoured contender, only achieved the placing of runner-up to the Bf 109 monoplane in all the important events.

Above A B.534 [illegible] the winter of [illegible] three B.534 dual-seat Slovak [illegible] finally [illegible] Poland [illegible]

Created by Ing František Novotný, the B.534 was without doubt a classic design and arguably carried the fighter biplane to its mid-thirties zenith. Its genesis lay in the B.33, a fabric-covered all-metal biplane flown during the summer of 1932. While retaining the fundamental structure the B.534, which flew as a prototype in August 1933, possessed little external resemblance to its progenitor, a second, even more refined prototype improving on an already advanced performance to establish a Czechoslovakian national speed record in April 1934.

Ordered into production on 17 July 1934, the B.534 was to be built in five series, each introducing equipment or aerodynamic refinements, to a total of 466 aircraft, including six for Greece and 14 for Yugoslavia, the definitive models being the Bk.534 (in which it was intended to displace two of the four 7.92-mm guns in favour of an engine-mounted 20-mm Oerlikon cannon—hence the prefix "k" for *kanón*, which proved unavailable) and B.534 IV (ie, IV série) with all-sliding cockpit canopy and raised aft fuselage decking.

On 1 September 1938, a total of 272 Bk.534 and B.534 fighters were included in the Order of Battle, and when six months later the Czechoslovak Republic was dissolved some 65 were taken by the new Slovak Air Force, 72 sold to Bulgaria and the remainder taken by the Luftwaffe.

SPECIFICATION B.534.IV

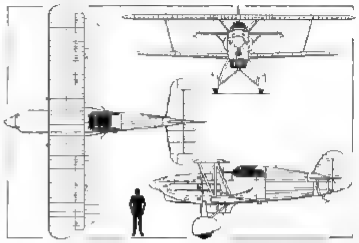
Power Plant: One Avia-built Hispano-Suiza 12Ydrs 12-cylinder vee liquid-cooled engine rated at 750 hp (for two min) at 2,400 rpm for take-off and 650 hp at 10,170 ft (3,100 m). Two-bladed fixed-pitch metal propeller. Internal fuel capacity 76.3 Imp gal (347 l).

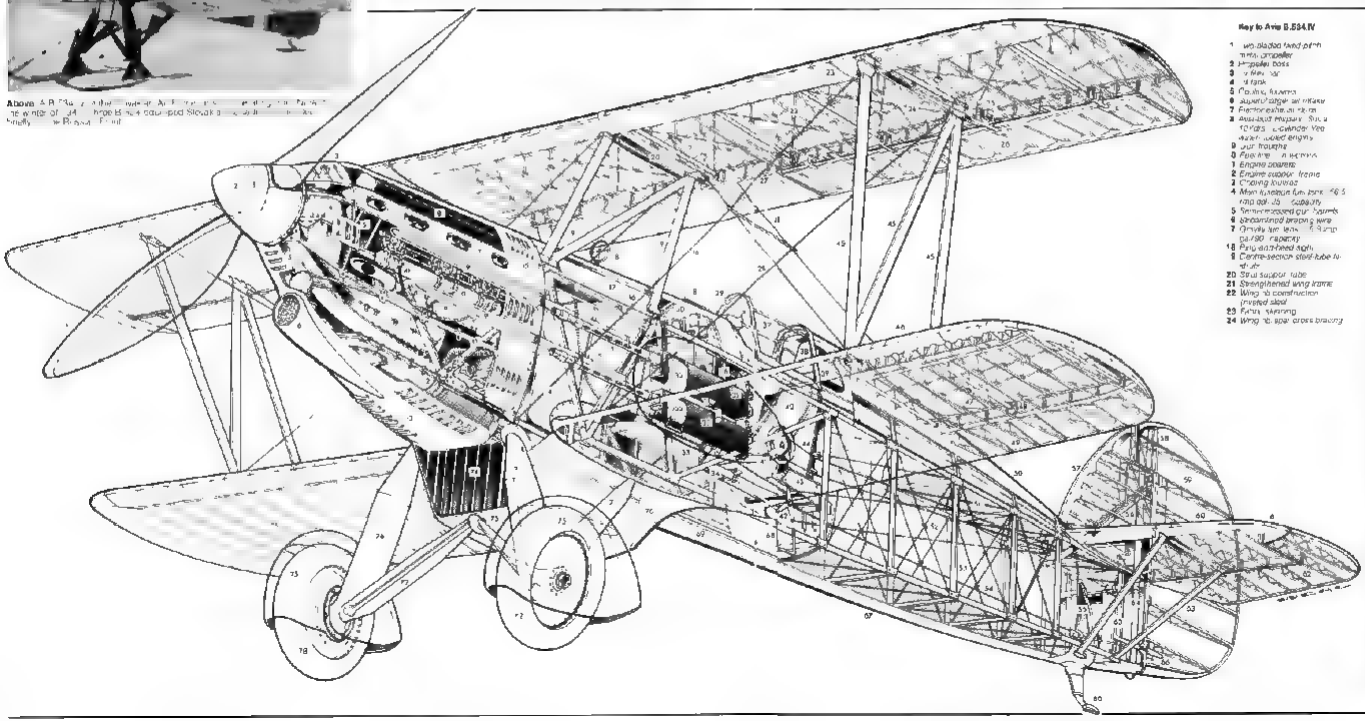
Performance: Max speed, 232 mph (375 km/h) at sea level, 245 mph (394 km/h) at 14,435 ft (4,400 m), max continuous cruise 214 mph (345 km/h) at 14,435 ft (4,400 m), max range, 360 mls (580 km); initial climb, 2,953 ft/min (15.0 m/sec), time to 16,405 ft (5,000 m) 4.47 min, service ceiling, 34,775 ft (10,600 m).

Weights: Empty equipped, 3,219 lb (1,460 kg); normal loaded, 4,376 lb (1,985 kg); max, 4,674 lb (2,120 kg).

Dimensions: Span, 30 ft 10 in (9.40 m), length, 26 ft 10⅞ in (8.20 m), height, 10 ft 2 in (3.10 m); wing area, 253.6 sq ft (23.56 m²).

Armament: Four 7.92-mm Model 30 machine guns with 800 rpg and provision for six 44-lb (20-kg) bombs on wing racks.





Key to Avia B.534.IV

1 Two-bladed fixed-pitch metal propeller
2 Propeller boss
3 [illegible]
4 Oil tank
5 Cooling louvres
6 Supercharger air intake
7 Fairing behind radiator
8 Hispano-Suiza 12Ydrs 12-cylinder Vee water-cooled engine
9 Gun trough
10 Rear engine mounting
11 Engine bearers
12 Engine support frame
13 Cooling louvres
14 Main fuselage fuel tank (76.3 Imp gal/347 l capacity)
15 Tension-wired cut frames
16 Undercarriage wing
17 Oleo-leg undercarriage (2 Imp gal/9 l capacity)
18 Fairing wire-braced
19 Fairing wire-braced
20 Strut support tube
21 Strengthened wing frame
22 Wing rib construction (riveted sheet)
23 Fairing stringers
24 Wing rib spar cross bracing
25 Aileron control hinge
26 Port (balanced) aileron
27 Rear spar
28 Bracing wires
29 One-piece curved windscreen
30 Instrument panel
31 Anti-vibration [illegible]
32 Cartridge chutes
33 [illegible]
34 Gun support frame
35 Two 7.92-mm Model 30 synchronised machine guns
36 Gun [illegible]
37 Three-position sliding canopy frame (Perspex)
38 Pilot's seat/pad
39 Rear-vision side glazing
40 Pilot's adjustable seat (converted to back-type parachute)
41 Tailplane incidence adjustment wheel
42 Elevator controls
43 Seat support frame
44 Control runs
45 Main fuselage stringers (N type shown)
46 Fabric-covered lower wing
47 Wing rib construction
48 Rear spar
49 Wing trailing-edge construction
50 Dorsal decking
51 Elevator [illegible]
52 Fuselage cross bracing
53 Fuselage rectangular steel tube framework (tube riveted and joined together and wire braced)
54 Rudder controls
55 Turned shock absorber
56 Tailplane support member
57 Tailplane construction (adjustable in ground)
58 Rudder beam
59 Rudder construction
60 Tailplane construction (riveted steel strip)
61 Elevator balance
62 Elevator construction
63 Steel-tube airframe struts
64 Rudder post
65 Rudder lower hinge
66 Tailskid (retractable with fairings and non-retractable shock absorber strut)
67 Fabric fuselage stringers
68 Entry step
69 Stringers
70 Ventral fairing fuel
71 Axle clip supporting port undercarriage strut
72 Dunlop-Bata non-marking wheel
73 Axle strut attachment point (hinged forward, aft bolts)
74 Temperature control shutters for ventral radiator
75 Wheel spats (usually removed to operation from grass fields)
76 Starboard undercarriage strut
77 Half-axle
78 Starboard main wheel

Polikarpov I-16 (December 1933)

Precursor of a new vogue in single-seat fighters in being the first cantilever monoplane with a retractable undercarriage to enter service, the I-16 briefly carried Soviet fighter development ahead of international standards. Its appearance was bizarre—its truncated fuselage with ponderous, abbreviated nose seemed better suited for a biplane—but aspect notwithstanding, the I-16 represented a very real advance in the state of the fighter art.

Designed by Nikolai N. Polikarpov, the I-16 employed a primarily fabric-covered two-spar metal wing mated with a wooden monocoque fuselage. Split type ailerons also fulfilled the function of landing flaps, the mainwheels were retracted by handcrank and the initial series featured a forward-sliding cockpit canopy, an item soon discarded. The first prototype (TsKB-12) was flown on 31 December 1933 and, as the I-16 Type 5, the fighter began to enter service early in 1935, making its combat debut over Spain in support of the Republican Government in November 1936.

If less suited than contemporary biplanes for close in, high-g manoeuvring combat, the I-16 was very manoeuvrable by the standards later established by similarly-configured fighters. Its ailerons were feather-light and offered an exceptional roll rate. It could perform such manoeuvres as loops and spins and S's with outstanding precision, and it possessed excellent zoom climb ability. It was only a reasonably satisfactory gun platform, however, and it was overly sensitive to control movements, the inertia moments around all three axes being extremely small. Longitudinal stability was marginal, and the I-16 tended to stall out of a glide, while with undercarriage extended it was excessively sluggish, power having to be kept up to avoid a wing drop and the aircraft having to be literally flown onto the ground.

More powerful Shvetsov radials and heavier armament were progressively introduced in the principal production series being the Types 6, 10, 17, 18 and 24, and 7,005 being built (plus 1,639 two-seat conversion trainers), but the advanced nature of the I-16 when first introduced did not have a salutary effect on subsequent Soviet fighter design effort. Long past the apex of its development, the I-16 formed some 65 per cent of the Soviet fighter inventory against the Luftwaffe in 1941, and was totally outclassed.

SPECIFICATION I-16 Type 10

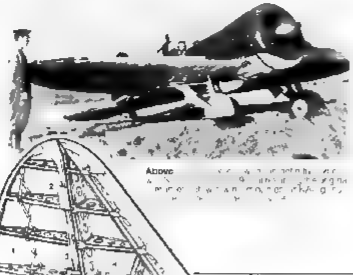
Power Plant: One Shvetsov M-25V (Cyclone SR-1820) nine-cylinder radial air-cooled engine rated at 775 hp at 2,000 rpm for take-off and 750 hp at 9,515 ft (2,900 m). Two-bladed AV-1 two-pitch metal propeller. Internal fuel capacity 56 Imp gal (255 l).

Performance: Max speed 242 mph (389 km/h) at sea level, 273 mph (440 km/h) at 9,840 ft (3,000 m); max range, 497 mls (800 km); time to 16,405 ft (5,000 m), 6·9 min; service ceiling 27,130 ft (8,270 m).

Weights: Empty equipped, 2,976 lb (1,350 kg); normal loaded, 3,781 lb (1,715 kg).

Dimensions: Span 29 ft 6 in (9·00 m); length 19 ft 7¾ in (5·99 m); height 8 ft 4¾ in (2·56 m); wing area, 156·51 sq ft (14·54 m²).

Armament: Four 7·62-mm Shpital'ny-Komaritsky ShKAS machine guns with 650 rounds of ammunition for each gun.



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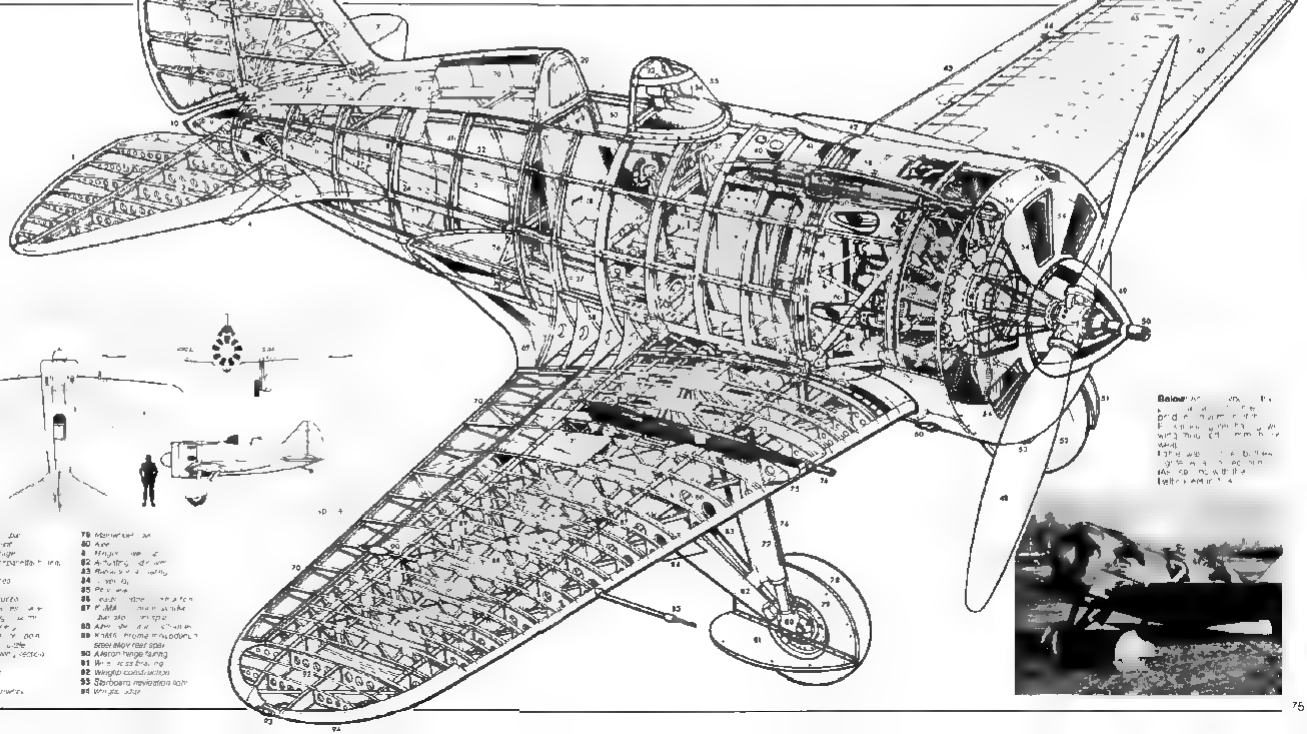

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Gloster Gladiator (September 1934)

Perhaps best described as the epitome of the British fighting biplane for whose epoch it sung the swan-song, the Gladiator was the synthesis of two decades of continuous Gloster fighter biplane evolution. Fated to be overtaken by technological development while still in gestation and an anachronism by the time it was to fire its guns in anger the Gladiator was a good aeroplane but lacked the greatness with which romanticism and nostalgia were later to endow it, the fact that it was ordered at all, reflected the conservatism of British officialdom of the day.

The Gladiator was admittedly a thoroughbred, but pedigree is scarcely an acceptable substitute for performance and firepower in war, and this, last of the British fighting biplanes was to suffer the misfortune of almost invariably operating under conditions of qualitative and quantitative enemy superiority. Conceived as a private venture to specification F7/30 and flown in prototype form (as the SS-37) on 12 September 1934, the Gladiator entered series production in the summer of 1935. Its only concessions to modernity being an enclosed cockpit, hydraulically operated flaps and the doubling of the previously-standard two-gun armament.

The first Gladiator Is were flown in January 1937; they were compact and aesthetically attractive aircraft, but few were the service pilots that did not prefer their lines predecessor the Gauntlet in all respects other than performance. Somewhat temperamental, the Gladiator was rarely forgiving, an engine-on stall was, as likely as not attended by a sudden wing drop and spin, the unwary discovering that the Gladiator then tended to reverse and enter a flat spin.

Whereas the Gladiator I, of which 378 were built, had a Mercury IX engine and a Watts two-bladed fixed-pitch wooden propeller, the Mk II had a similarly-rated Mercury VIIIA or AS with a Fairey Reed three-bladed fixed-pitch metal propeller, and 270 of the later version were built together with 98 completed as Sea Gladiator shipboard fighters. A total of 166 was exported to nine countries, and 118 ex RAF Gladiators were transferred to other air forces during the war years. The last Gladiators still serving operationally with the RAF being withdrawn during 1942 after giving notewor by performances in action in Norway, the defence of Malta, the Western Desert and Greece.

SPECIFICATION: Gladiator II

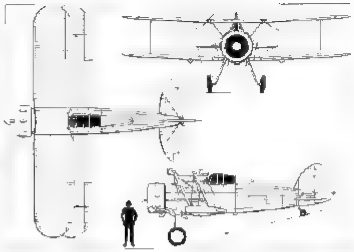
Power Plant: One Bristol Mercury VIIIA or VIIIAS nine-cylinder radial air-cooled engine rated at 725 hp at 2,750 rpm for take-off and 830 hp at 14,500 ft (4 420 m). Fairey Reed three-blade fixed-pitch metal propeller. Internal fuel capacity, 84 Imp gal. (382 l).

Performance. Max speed, 215 mph (346 km/h) at sea level, 226 mph (364 km/h) at 5,000 ft (1 525 m), 249 mph (400 km/h) at 10,000 ft (3 050 m), 257 mph (413 km/h) at 14,500 ft (4 450 m), range 344 mls (714 km) at 225 mph (362 km/h) at 14 600 ft (4 450 m); initial climb 2 430 ft/min (12,34 m/sec), time to 4,000 ft (1 220 m) 1 42 min, to 8 000 ft (2 440 m) 2·9 min, to 15,000 ft (4 570 m) 5·68 min.

Weights. Empty equipped, 3,847 lb (1 745 kg); normal loaded 4 864 lb (2 206 kg).

Dimensions. Span, 32 ft 3 in (9 83 m); length, 27 ft 5 in (8,36 m), height (tail down and over propeller disc), 10 ft 7 in (3,22 m); wing area 323 sq ft (30,01 m²).

Armament. Four 0 303 in (7 7 mm) BSA Colt Browning machine guns, with 600 rpg for fuselage-mounted pair and 400 rpg for wing-mounted pair.



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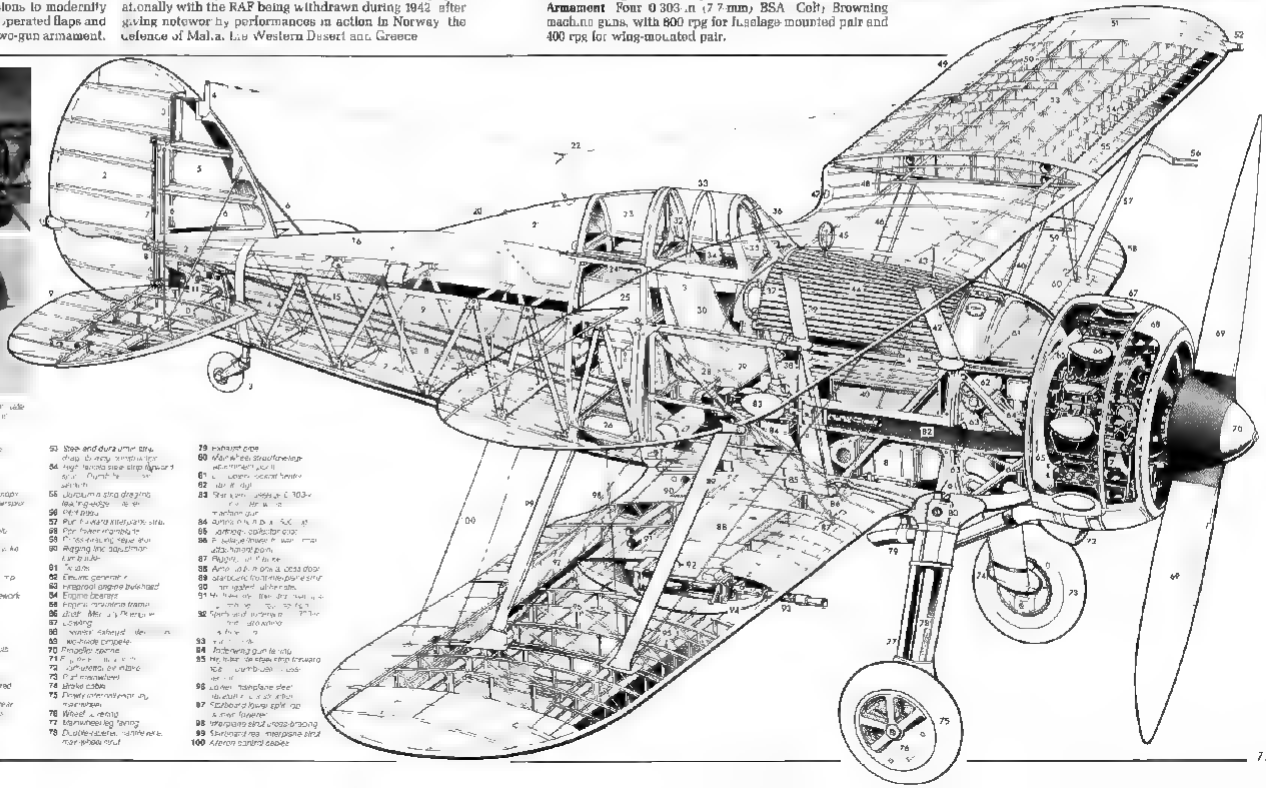

Key to Gloster Gladiator I

1 Rear navigation light
2 Rudder
3 Rudder balance
4 Rudder post
5 Tailplane
6 Tailplane leading edge
7 Rudder post
8 Rudder hinge
9 Starboard elevator
10 Tailplane adjustment screw
11 Tailplane adjustment screw
12 Elevator
13 Tailwheel
14 Rudder control cable
15 Rudder control cable
16 Undercarriage spring
17 Fuselage cross-bracing
18 Light metal fuselage to metal
19 Fuselage frame
20 Fuselage longeron
21 Cross-bracing
22 Spring
23 Rear cockpit glazing
24 Elevator trim
25 Rear hinge connection
26 Control cable to elevator
27 Control cable to elevator
28 Header tank
29 Fuselage
30 Step in fuselage
31 Hinged step-flap
32 Turtle deck
33 Rear sliding cockpit canopy (Red turtle indicates Parachute)
34 Wireless aerial
35 Radiator
36 Stabilizer
37 Elevator
38 Control
39 Control
40 Fuselage
41 Fuselage
42 Control
43 Fuselage
44 Cockpit
45 Arming
46 Port wing
47 Port wing
48 Port wing
49 Port wing
50 Hydraulic
51 Port
52 Port navigation light
53 Steel and duralumin strut
54 High tensile steel strip
55 Duralumin
56 Duralumin strip
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74 Brake
75 Power
76 Wheel
77 Aluminium
78 Double-
79 Exhaust
80 Wire
81 Wire
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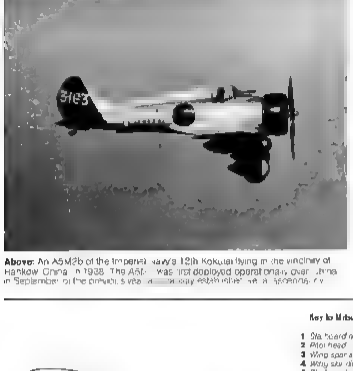
100 Aileron control cable

Mitsubishi A5M (February 1935)



Above: An A5M2b of the Imperial Navy's 12th Kokutai flying in the vicinity of Hankow, China, in 1938. The A5M was first deployed operationally over China in September of the preceding year, a year after it had been officially established as a promising fighter.

Claiming the distinction of being the world's first service shipboard single-seat cantilever monoplane fighter, the A5M (or Type 96) did more than any aircraft to raise Japanese aeronautical design and manufacture to world standard. An attempt to translate the qualities of the biplane into terms of the monoplane, close-in dogfighting prowess still taking precedence in Japan over all other qualities, the A5M was radical insofar as was concerned carrier aviation and was arguably the most agile fighter monoplane ever built.

Designed by Jiro Horikoshi, in the imaginative and singularly demanding requirements of a 9-Shi (1934) specification calling for a quantum performance advance the A5M was aerodynamically very clean, had a comparatively light all-metal flush-riveted stressed skin structure and was equipped with landing flaps. The first prototype (Ka-14) flew on 4 February 1935, production being initiated as the A5M1 in the following year on the basis of a revised second prototype, service debut taking place early 1937.

The A5M2a with uprated engine was the first model employed operationally, appearing over China in September 1937, and giving place to the A5M2b with three-bladed propeller and (quickly discarded) cockpit canopy. The definitive version with further engine uprating, the A5M4, appeared in 1938, production continuing into 1941 to bring the total of single-seat models, excluding prototypes, to 982.

SPECIFICATION: A5M4

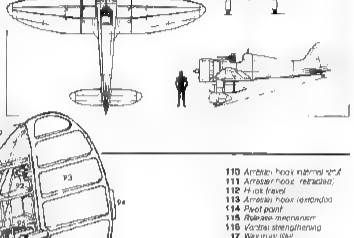
Power Plant: One Nakajima Kotobuki 41 nine-cylinder radial air-cooled engine rated at 710 hp at 2,600 rpm for take-off and 785 hp at 9,845 ft (3 000 m). Three-blade SS 22 two-pitch (ground adjustable) metal propeller. Internal fuel capacity, 76 Imp gal (346 l), with provision for 35 Imp gal (160 l) or 46 Imp gal (210 l) auxiliary tank.

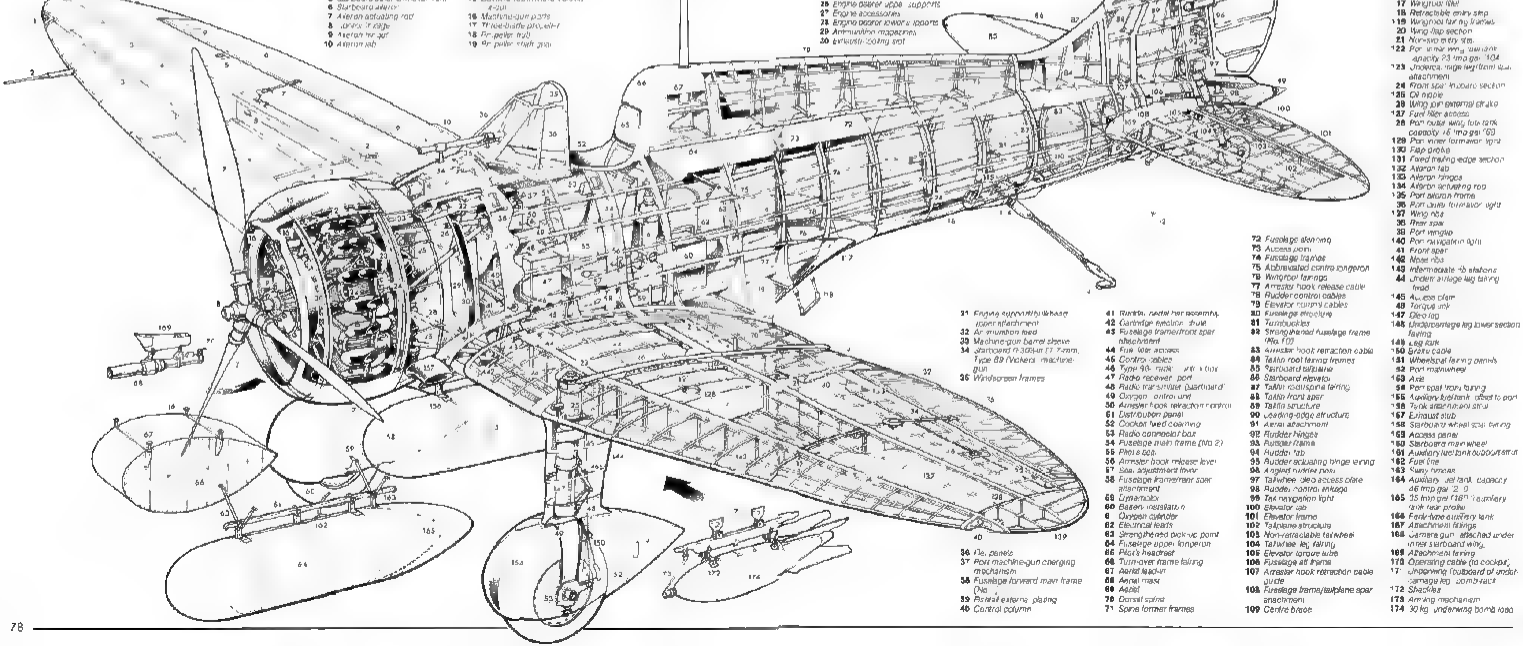
Performance: Max speed 236 mph (380 km/h) at sea level, 248 mph (398 km/h) at 3 280 ft (1 000 m), 270 mph (434 km/h) at 9,845 ft (3 000 m); range (internal fuel), 500 mls (805 km) at 250 mph (402 km/h) at 9,845 ft (3 000 m) (with 35 Imp gal (160 l) auxiliary tank), 746 mls (1 200 km); time to 9,845 ft (3 000 m), 3·58 minutes; service ceiling, 32 150 feet (9 800 metres).

Weights: Empty equipped, 2,681 lb (1 216 kg); normal loaded, 3,684 lb (1 671 kg); max, 3 763 lb (1 707 kg).

Dimensions: Span, 36 ft 1½ in (11 00 m); length 24 ft 9¾ in (7,56 m); height, 10 ft 8¾ in (3,27 m); wing area, 191·6 sq ft (17.80 m²).

Armament: Two 7,7-mm Type 89 machine guns with 500 rpg and provision for two 66-lb (30-kg) bombs.





Grumman F3F (March 1935)

By a quirk of fate, carrier-based biplane fighter performance was to be carried to its ultimate by *force majeure* rather than intent. The aircraft to achieve the peak performance levels being the last of the barrel-like biplane progeny of Leroy Grumman and his associates of the youthful Grumman Aircraft Engineering Corporation. When the first of the genre, the F2F-1, had made its debut aboard the USS *Lexington* in February 1935, it carried US naval aviation a major step forward in fighter technology, when the definitive F3F-3 went aboard USS *Yorktown* in May 1939, it was an anachronism and was phased out of first line service in 1941.

The competent F2F-1 had introduced to the shipboard single-seat fighter such embellishments as a cockpit canopy and retractable undercarriage. It demonstrated an outstanding performance by contemporary standards, but the advances that it had betokened had extracted penalties in the form of poor directional stability and a tendency to wind-up in a spin. In an attempt to mate further performance enhancement with more acceptable handling characteristics, the basic design was aerodynamically refined and the fuselage marginally stretched, and as the XF3F-1 the modified aircraft flew on 20 March 1935.

Notably more manoeuvrable with exceptional handling characteristics, very light stick forces and much improved directional stability, albeit retaining what were considered to be dangerous spinning traits, the refined model was ordered into production as the F3F-1, 54 being delivered in 1936. Replacement of the Twin Wasp Junior engine with the higher-powered Cyclone resulted in delivery of 81 F3F-2s from mid 1937, here manufacture of the shipboard fighter biplane for the US Navy and USMC *should* have ended.

In the event, the successful coalescence of nautical and aeronautical requirements in so far as the new generation of fighter monoplanes was concerned, an endeavour in which Japan had incidentally taken the vanguard with the A5M, was proving more time-consuming than had been anticipated. Thus, a further order was placed for the now conceptually obsolete Grumman biplane. This called for 27 F3F-3s embodying various drag-reducing refinements.

SPECIFICATION, F3F-3

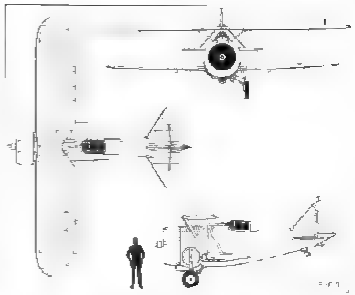
Power Plant: One Wright R-1820-22 Cyclone nine-cylinder radial air-cooled engine rated at 950 hp at 2,200 rpm for take-off and 750 hp at 15,200 ft (4,635 m). Three-blade Hamilton Standard metal, controllable-pitch propeller. Internal fuel capacity 108 Imp gal (492 l) including 39 Imp gal (178 l) reserve tank.

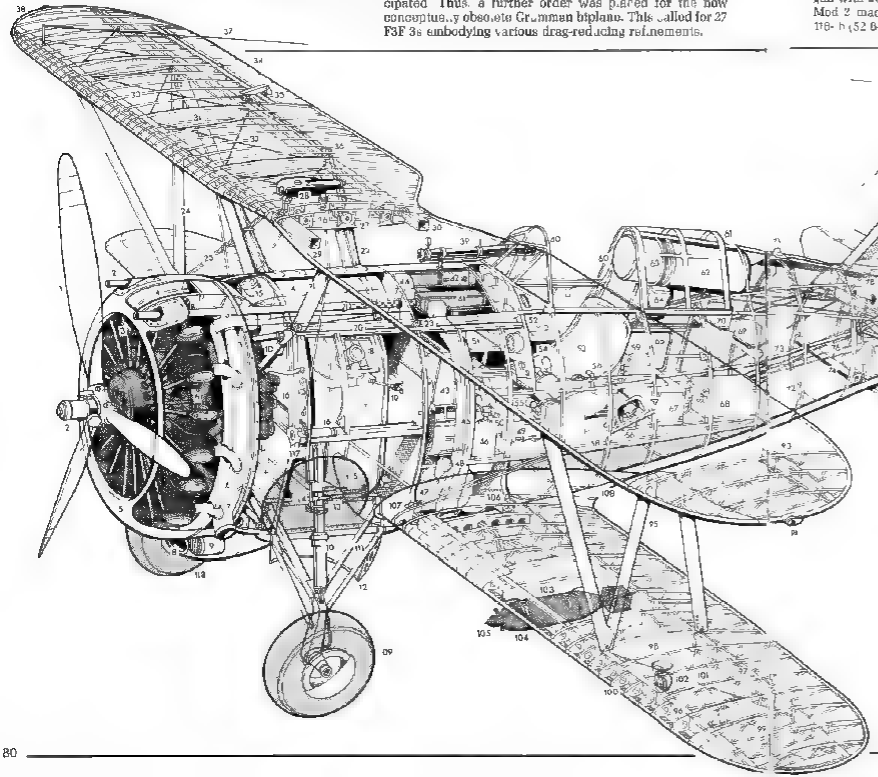
Performance: Max speed, 239 mph (384 km/h) at sea level, 264 mph (425 km/h) at 15,200 ft (4,635 m); normal range 980 mls (1,577 km) at 128 mph (206 km/h), (with reserve tank) 1,150 mls (1,850 km); initial climb 2,760 ft/min (13·97 m/sec); service ceiling, 33,200 ft (10,120 m).

Weights: Empty equipped, 3,285 lb (1,490 kg); normal loaded 4,545 lb (2,061 kg); max 4,795 lb (2,175 kg).

Dimensions: Span, 32 ft 1 in (9·75 m); length, 23 ft 0 in (7·01 m); height (propeller vertical), 9 ft 4 in (2·84 m); wing area 260·6 sq ft (24·21 m²).

Armament: One 0·50 in (12·7 mm) Browning Mod 2 machine gun with 200 rounds and one 0·30 in (7·62 mm) Browning Mod 2 machine gun with 500 rounds. Provision for two 116-lb (52·6-kg) Mk IV bombs.





Key to Grumman F3F-3

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Right: [illegible] which was deployed [illegible] drag on the later version of the fighter.

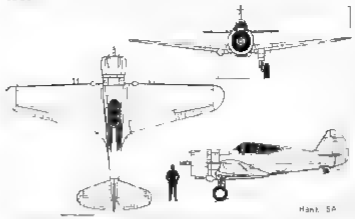
Curtiss Hawk 75A (April 1935)

To claim for the Allies the first aerial victories of WWII in both European (when flown by the Armée de l'Air) and Pacific (flown by the USAF) conflicts the Hawk 75A, alias P-36, had represented something of a watershed in US fighter development when flown as a prototype in mid April 1935. Few fighters were ever to carry a wider diversity of national markings or demonstrate greater ubiquity.

Designed by Donovan Reese Berlin as the Curtiss contender in a US Army pursuit contest that originally scheduled for May 1935 was to prove a positive catalyst in US fighter design, the new warplane owed nothing to the company's long experience with this combat aircraft category. Combining low-wing cantilever monoplane configuration with aluminium alloy semi-monocoque fuselage and multi-spar metal wing with flush riveted smooth Alclad skinning, hydraulically-actuated split flaps and retractable undercarriage and an aft-sliding cockpit canopy, Berlin's design represented an advance in the state of the art.

The combination of individual features was not, in itself, revolutionary – similar lines of development were being pursued contemporaneously in Europe – but was undeniably audacious and resulted in a truly classic design which was arguably the most advanced fighter in the world at the time of its début. Within such was the fantastic tempo of fighter development in the second half of the 1930s, that the Hawk 75A was to prove inferior in vital performance aspects to the majority of its antagonists. Offering superlative manoeuvrability, delightful handling characteristics and beautifully harmonised controls, it nevertheless lacked the climb-and-dive performance, acceleration and level speed to enable it to compete on even terms within two years of its service entry.

While the original contest was to be lost to the less advanced Seversky contender (see pages 90-91), the Curtiss fighter was the winner in the long run, with 227 being sold to the US Army as P-36s and a further 753 being exported as the Hawk 75A, the largest single recipient being the Armée de l'Air which ordered it with both twin-row Pratt & Whitney Twin Wasp and single-row Wright Cyclone radial engines, those undelivered at the time of France's capitulation being inherited by Britain where they promptly received the appellation of Mohawk (Mohawk I.I with Pratt & Whitney Twin Wasp, Mohawk IV with Wright Cyclone) serving in the Middle East, India and Burma until the beginning of 1944.



SPECIFICATION: Hawk 75A-4 (Mohawk IV)

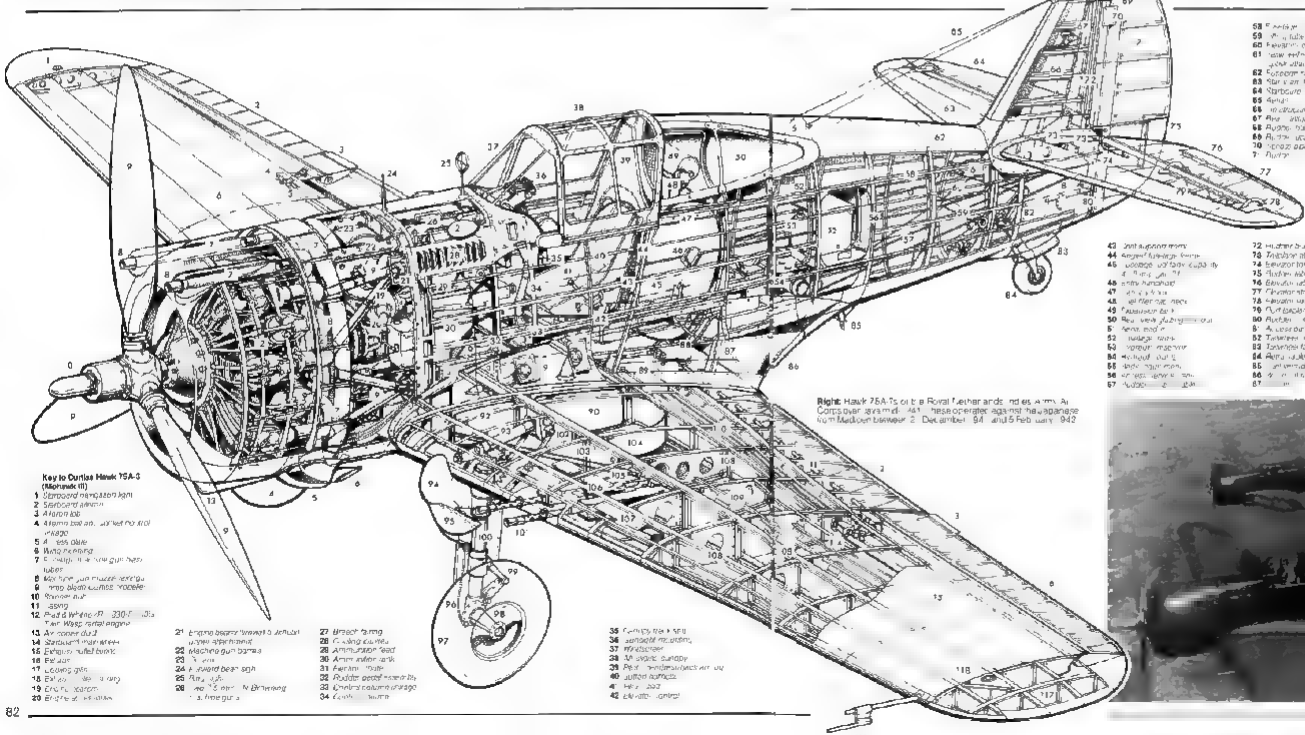
Power Plant: One Wright GR1820-G205A (R-1820-87) Cyclone nine-cylinder radial, air-cooled engine rated at 1,200 hp at 2,500 rpm for take-off, 1,200 hp at 4,200 ft (1,280 m) and 1,000 hp at 14,200 ft (4,330 m). Three-blade constant-speed Curtiss propeller. Internal fuel capacity, 87 Imp gal (387 l), including 48 Imp gal (217 l) in optional fuselage tank.

Performance. Max speed, 323 mph (520 km/h) at 15,100 ft (4,600 m), 272 mph (438 km/h) at sea level; typical cruise, 262 mph (422 km/h) at 10,000 ft (3,050 m); normal range, 670 mls (1,078 km), (with fuselage tank), 1,010 mls (1,625 km). Initial climb, 2,620 ft/min (14.32 m/sec); service ceiling, 32,700 ft (9,965 m).

Weights. Empty equipped, 4,541 lb (2,060 kg); normal loaded, 5,750 lb (2,608 kg).

Dimensions. Span, 37 ft 4 in (11.38 m); length, 28 ft 7¾ in (8.74 m); height, 9 ft 3 in (2.82 m); wing area, 236 sq ft (21.92 m²).

Armament: Six 7.5-mm FN-Browning Mle 38 machine guns with 600 rpg (fuselage) and 500 rpg (wing).



Key to Curtiss Hawk 75A-3 (Mohawk III)

1 Starboard navigation light
2 Starboard aileron
3 Aileron tab
4 Aileron tab actuating rod linkage
5 Aileron tab
6 Wing rib
7 Fairing for wing gun feed tubes
8 Machine gun muzzle extension
9 Prop blade (Curtiss Propeller)
10 Spinner cap
11 Cowling
12 Pratt & Whitney R-1830-[illegible] Twin Wasp radial engine
13 Air cooler duct
14 Starboard main wheel
15 Extension fuel tank
16 Fairing
17 Cooling gills
18 Exhaust [illegible]
19 Engine [illegible]
20 Engine [illegible]
21 Engine beam forward to fuselage attachment
22 Machine gun barrels
23 [illegible]
24 [illegible] beam [illegible]
25 Flap [illegible]
26 [illegible] FN Browning [illegible] machine gun
27 Breech housing
28 Cooling [illegible]
29 Ammunition feed
30 Ammunition [illegible]
31 Fairing [illegible]
32 Rudder pedal assembly
33 Control column linkage
34 Control column
35 Control [illegible]
36 Longitudinal [illegible]
37 Windscreen
38 Upward [illegible] canopy
39 Pilot [illegible] seat
40 Seat [illegible]
41 Heater [illegible]
42 Elevator control
43 Port elevator [illegible]
44 Elevator linkage [illegible]
45 Elevator [illegible] tab [illegible]
46 Elevator [illegible]
47 Elevator [illegible]
48 Elevator [illegible]
49 Fuselage [illegible]
50 Rear [illegible]
51 Aerial mast
52 Fuselage [illegible]
53 Tailplane [illegible]
54 Port tailplane [illegible]
55 Rudder [illegible]
56 Rudder [illegible]
57 Rudder [illegible]
58 Rudder [illegible]
59 Rudder [illegible]
60 Elevator [illegible]
61 Rear [illegible] [illegible]
62 Fuselage [illegible]
63 Starboard [illegible]
64 Starboard [illegible]
65 Aerial
66 Ventilation
67 Rear [illegible]
68 Rudder [illegible]
69 Rudder [illegible]
70 Fairing [illegible]
71 Fairing
72 Heater duct
73 Radiator attachment points
74 Elevator torque tube
75 Rudder rod
76 Elevator rod
77 Elevator torque tube
78 Elevator balance horn
79 Port elevator
80 Rudder [illegible]
81 Rudder [illegible]
82 Tailplane fairing [illegible]
83 Port tailplane
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100 Main [illegible]
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108 Wing [illegible]
109 Wing [illegible]
110 Aileron [illegible]
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113 Aileron [illegible]
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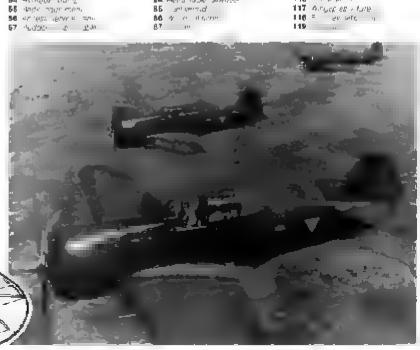
Right: Hawk 75A-1s of the Royal Netherlands Indies Army Air Corps over Java in [illegible] 1941. These operated against the Japanese from Medoen between 2 December 1941 and 15 February 1942.



Messerschmitt Bf 109 (May 1935)

Above

When the first prototype Bf 109 commenced flight testing late in May 1935 as the first single-seat fighter to combine with the low-wing cantilever monoplane configuration a flush-riveted all-metal stressed-skin monocoque structure, a retractable undercarriage and an enclosed cockpit, it was evolutionary rather than revolutionary. Its features had all been used individually by other aircraft but not previously combined in one airframe.

Willy Messerschmitt and his co-designer, Robert Lusser, took full advantage of the most advanced aerodynamics and structural techniques of the day: the result was an inspired creation. By comparison with its contemporary and future antagonist, the Spitfire (see pages 86-89), it possessed a much higher wing loading, but compensated for this to some extent by use of the then-radical combination of automatic leading-edge slots and slotted trailing-edge flaps. Its creators had made no concessions to the traditionalists.

A well-conceived, soundly-designed fighter, the Bf 109 was to maintain its maturity the success that was to attend its infancy: its fundamental concept facilitating the introduction of progressively more powerful engines and armament enabling it to stay in the forefront of its class for three-quarters of the decade that witnessed the most dramatic increase in the tempo of fighter evolution.

The first prototype, the Bf 109 V1, was powered by a Rolls-Royce Kestrel V engine, the V2 and V3, flown in January and June 1936 respectively, had the Jumo 210, retained for the Bf

continued on page 85 ▶

SPECIFICATION: Bf 109E-3

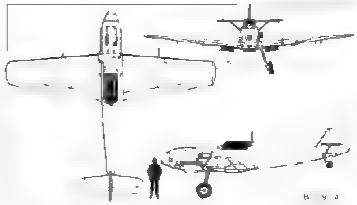
Power Plant: One Daimler-Benz DB 601Aa 12-cylinder inverted-vee liquid-cooled engine rated at 1,1[illegible]5 hp at 2,400 rpm for take-off and 990 hp at 12,140 ft (3,700 m). Three-blade VDM constant-speed metal propeller. Internal fuel capacity, 88 Imp gal (400 l).

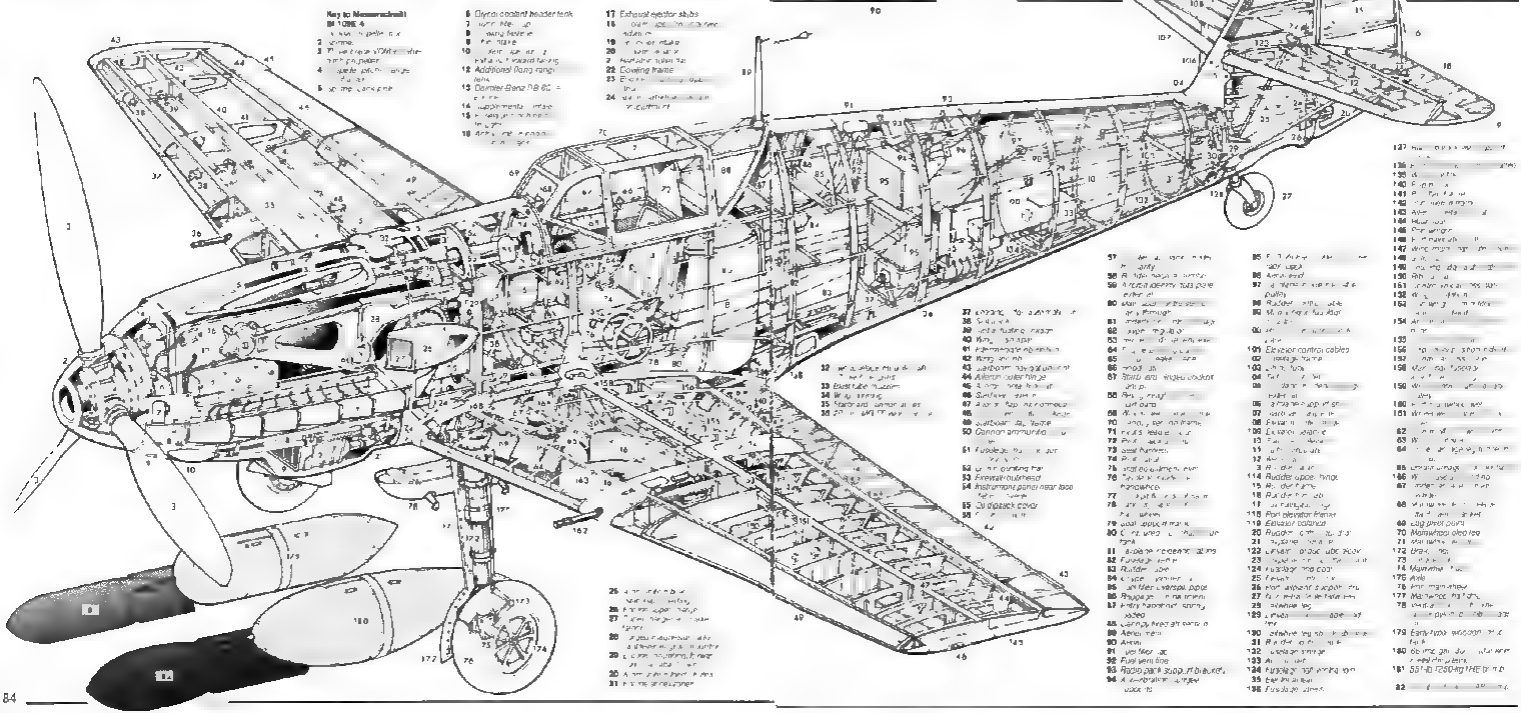
Performance: Max speed 290 mph (467 km/h) at sea level, 307 mph (494 km/h) at 3,280 ft (1,000 m), 348 mph (560 km/h) at 14,560 ft (4,440 m); max cruise, 300 mph (483 km/h) at 13,120 ft (4,000 m); range cruise, 210 mph (338 km/h) at 6,560 ft (2,000 m); max range, 410 mi (660 km); initial climb (at 5,400 lb, 2,450 kg), 3,280 ft/min (16.66 m/sec); time to 9,840 ft (3,000 m), 3.6 min; to 19,685 ft (6,000 m), 7.75 min; service ceiling, 34,450 ft (10,500 m).

Weights: Empty, 4,189 lb (1,900 kg); empty equipped, 4,885 lb (2,125 kg); loaded, 5,875 lb (2,665 kg).

Dimensions: Span, 32 ft 4½ in (9.87 m); length 28 ft 4½ in (8.64 m); height 8 ft 2[illegible] in (2.50 m); wing area, 174.05 sq ft.

Armament: Two 20-mm MG FF (Oerlikon) cannon with 60 rpg and two 7.9-mm Rheinmetall-Borsig MG 17 machine guns with 1,000 rpg.





Messerschmitt Bf 109

cont ▸ 109B, C and D series. The first Bf 109Bs left the assembly lines in February 1937 and by March were in Spain with the Legion Condor, establishing an enviable reputation. Late in 1938 the Bf 109E entered service, mating the basic airframe with the more powerful DB 601 engine and, as the Bf 109E-3, introducing wing-mounted cannon armament.

The Bf 109E offered excellent handling characteristics and response at low and medium speeds, a good low-speed climb angle and a gentle stall without any tendency to spin. Climb and dive were second to none, but the controls heavied up with speed and manoeuvrability was found wanting in the Battle of Britain, this proving a conflict having a salutary effect on the Messerschmitt fighter's evolution. Aerodynamic refinement and an uprated engine characterised the Bf 109F, which appeared operationally spring 1941, and carried, according to some Luftwaffe pilots, the basic design to the zenith of its development cycle, tighter weight and power loadings thereafter being accompanied by progressive deterioration of handling qualities and manoeuvrability, although, by consensus, these were considered acceptable penalties in exchange for higher speeds and increased versatility.

A significant further stage in this weight escalation was provided by the DB 605-powered Bf 109G, which achieved operational status in the spring of 1942 and was to be built in infinitely larger numbers than any other Bf 109 sub-type. Built in multifarious forms, the immense differences between site models, such as the Bf 109G-14 of early 1944 and the Bf 109G-4 of mid 1940, dramatically reflected the changing demands of the air war. In September 1944, as the war in Europe drew to its close, the ultimate production variant of the Messerschmitt fighter made its appearance. This, the Bf 109K, employed the very much more powerful DB 605D series engine and incorporated all the progressive developments introduced in earlier Bf 109G versions.

Built in larger numbers than any other combat aeroplane before or since and employed on every front to which the Luftwaffe was committed, the Bf 109 was an extraordinarily durable warplane and a true classic.

SPECIFICATION: Bf 109G-6

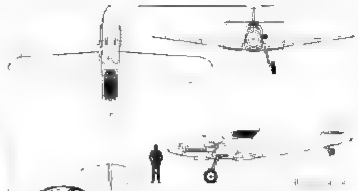
Power Plant. One Daimler-Benz DB 605AM 12-cylinder inverted-vee liquid-cooled engine rated at 1,475 hp at 2,800 rpm (or 1,800 hp with MW 50 methanol-water injection) for take-off. Three-blade VDM constant-speed metal propeller. **Internal fuel capacity** 88 imp gal (400 l), with provision for one 66 imp gal (300 l) auxiliary fuel tank.

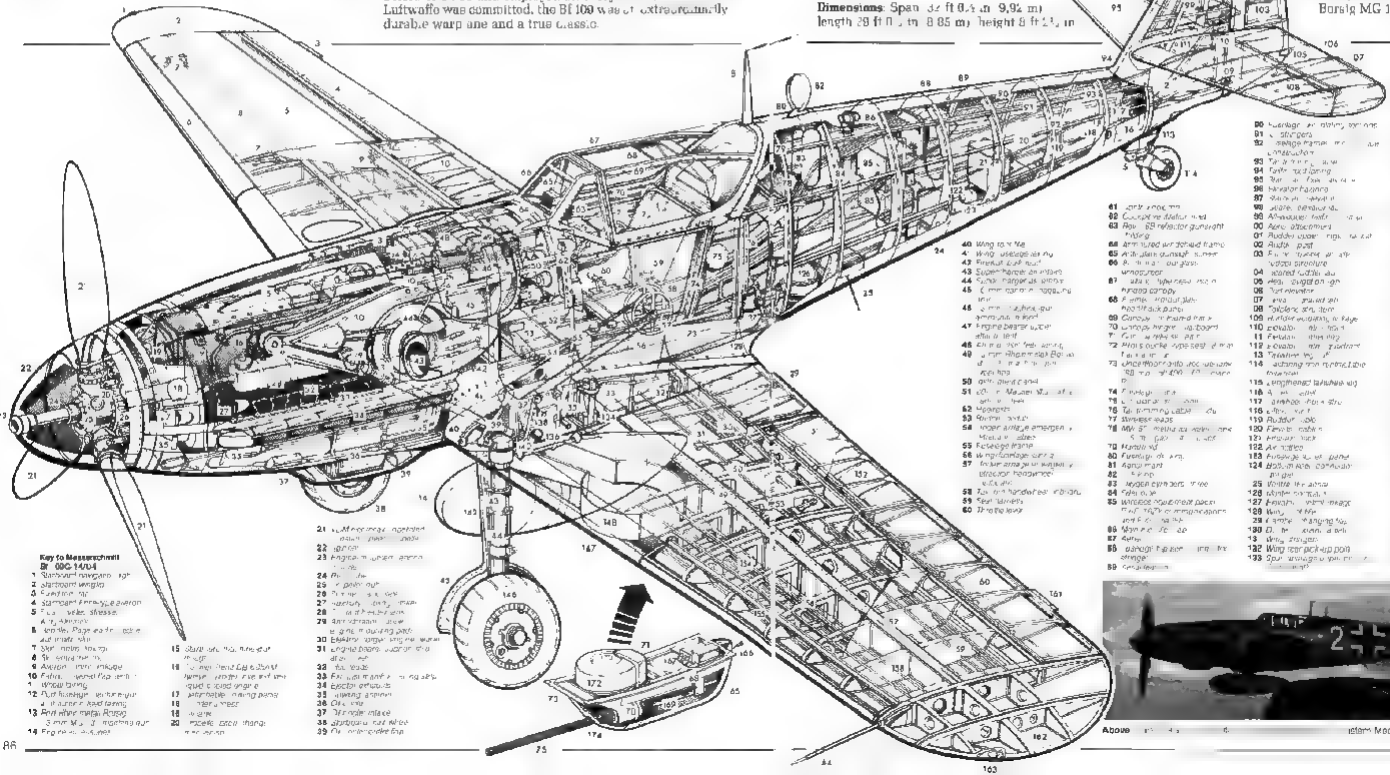
Performance: Max speed 340 mph (547 km/h) at sea level, 366 mph (590 km/h) at 6,560 ft (2,000 m), 380 mph (611 km/h) at 13,120 ft (4,000 m), 386 mph (621 km/h) at 22,640 ft (6,900 m); range (internal fuel) 350 mls (563 km) at 330 mph (530 km/h) at 19,030 ft (5,800 m), with auxiliary tank, 620 mls (998 km) at 317 mph (510 km/h) at 19,685 ft (6,000 m); initial climb 3,346 ft/min (17 m/sec); time to 9,840 ft (3,000 m) 2·9 min; service ceiling 37,896 ft (11,550 m).

Weights: Empty equipped 5,893 lb (2,673 kg); normal loaded 6,940 lb (3,148 kg); max overload 7,496 lb (3,400 kg).

Dimensions: Span 32 ft 6¾ in (9,92 m); length 29 ft 0½ in (8,85 m); height 8 ft 2½ in (2·50 m); wing area 173·3 sq ft (16·10 m²).

Armament: One 30-mm Rheinmetal Borsig MK 108 cannon with 65 rounds (or 20-mm Mauser MG 151 with 150 rounds) and two 13-mm Rheinmetal Borsig MG 131 machine guns with 300 rounds per gun.





Key to Messerschmitt Bf 109G-14/U4

1 Rainproof navigation light
2 Starboard wingtip
3 Aileron tip
4 Starboard aileron balance
5 Aileron hinge
6 Aileron control linkage
7 Aileron horn
8 Wing spar
9 Aileron control linkage
10 Fairing
11 Wing fairing
12 Port fuselage lightening gutter (underfuselage)
13 Port wing metal fairing
14 Engine cowling panel
15 Spare wing fairing panel
16 Port wing fairing panel
17 Port wing tip
18 Port navigation light
19 Wing
20 Wing root fairing
21 Port wing root fairing panel
22 Aileron
23 Aileron balance panel
24 Port aileron
25 Aileron spar
26 Aileron control linkage
27 Aileron control linkage
28 Aileron control linkage
29 Port aileron balance panel
30 Fairing
31 Engine bearer support frame
32 Exhaust
33 Exhaust manifold
34 Exhaust
35 Cooling gill
36 Oil cooler
37 Air scoop intake
38 Supercharger intake
39 Oil cooler duct
40 Wing root fairing
41 Port wing root fairing
42 Port wing root fairing
43 Port wing root fairing
44 Port wing root fairing
45 Port wing root fairing
46 Port wing root fairing
47 Engine bearer support
48 Port wing root fairing
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52 Wing root fairing
53 Wing root fairing
54 Wing root fairing
55 Fuselage frame
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175 Port wing root fairing

Above: [illegible] Mediterranean 1943

Morane-Saulnier M.S. 406 (August 1935)

Contemporary with the Hurricane (see pages 92-93 and) likewise a synthesis of years of fighter design experience trans ated into terms of low-wing cantilever monoplane, the M S 4.6 provided an outstanding example of the rapidity with which, in the 'thirties an indifferent des gn could trans ate to the patently obsolescent. An aesthetically unattractive aeroplane with few pretensions to elegance the M S 406, by the standards of the day, could lay c a m to no more than a certain functional sturdiness an [illegible] pleasant handling characteristics reminiscent of those of the fighter generation that it was intended to supplant.

Designed by R Gauthier to fulfil a specification issued in September 1934, the Morane-Saulnier fighter represented a more conservative structural approach to the requirement than its more fashionable competitors retaining classic steel-tube construction, with, apart from fabric-covered aft fuselage and control surfaces Plymax [illegible] plywood bonded to aluminium stressed skinning. It was first flown on 8 August 1935 as the M.S.405 being ordered into production as the M S 406, and the last of 16 pre-series aircraft being completed and flown on 21 June 1938 as a pattern aircraft for the prod ction model almost three years after the initiation of flight testing.

Production aircraft were slow to follow, fewer than a dozen having been taken on charge by 1 January 1939, by which time the M.S.406 had already been rendered thoroughly obsolescent by fighter development abroad. However, a production tempo of six daily had been attained by April and 11 daily four months later, the M S 406 being number ally the most important Armee de l Air fighter by the time France went to war in September 1939. 12 M S 406-equipped Groupes de Chasse being included in the Order of Battle.

It was soon abundant y clear that the M S 406 was ineffectual in compat with the Bf 109E. It was seriously underpowered at anything approach ng its alleged maximum speed the ethylene-glyco rad ator was retracted and the engine rapidly overheated; a lack f hydraulics resulted in the mainwheels popping out of their wells with application of positive g and the cold of altitude resulted in the pneumatic machine gun actuation and propeller pitch change [illegible] zing solu Production (1 08) ended March 1940

SPECIFICATION: M.S.406

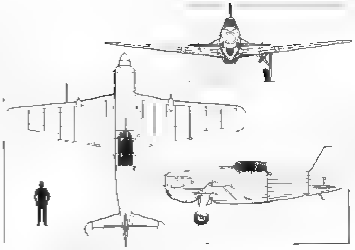
Power Plant: One Hispano-Suiza 12Y 31 12-cylinder vee liquid cooled engine rated at 830 hp at 2,400 rpm for take-off and 860 hp at 10 335 ft 3 150 m Three-bladed two-pitch metal Chauviere 351M propeller Internal fuel capacity 90 2 Imp ga (410 l)

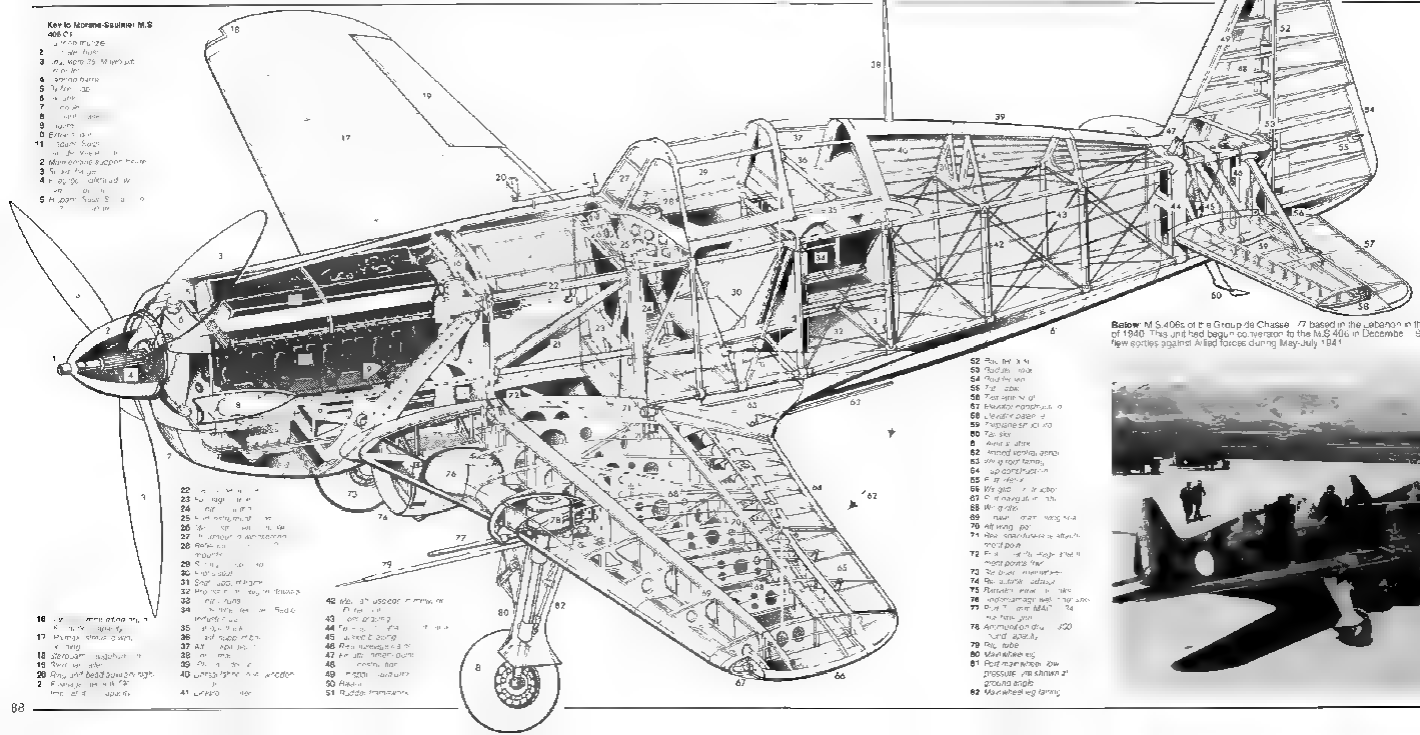
Performance. Max speed, 249 mph (401 km h) at sea leve 271 mph (437 km h) at 6,560 ft (2 000 m), 289 mph (465 km h) at 13 125 ft (4 000 m), econ cruise, 199 mph (320 km h), max range, 565 mls (910 km) at 196 mph (315 km h) at 19,685 ft (6 000 m), 621 mls (1 000 km) at 166 mph (267 km h) at 3 280 ft (1 000 m) initial climb, 2,559 ft min (13 m sec service ceiling 31 640 ft (9 400 m)

Weights. Empty equipped 4,173 lb (1 893 kg) normal loaded 5 348 lb (2 426 kg) max 5,511 lb (2 500 kg)

Dimensions: Span, 34 ft 8¾ in (10.62 m) length 26 ft 8½ in (8 17 m) height [illegible] 8 ft 10¾ in (2.71 m) wing area, 184 07 sq ft (17 10 m²)

Armament One 20-mm Hispano-Suiza S9 or HS 404 cannon with 60 rounds and two 7.5-mm MAC 1934 machine guns with 300 rpg





Key to Morane-Saulnier M.S 406 C1

Below M S 406s of the Groupe de Chasse [illegible] based in the Lebanon in the spring of 1940 This unit had begun conversion to the M.S 406 in December 1939 and flew sorties against Axis forces during May-July 1941

Seversky P-35 (August 1935)

If the P-35 had any title to fame it was the somewhat tenuous claim of having introduced to US Army Air Corps fighter aviation such refinements as an enclosed cockpit, a constant-speed propeller and a retractable undercarriage. The end product of a strange series of metamorphoses imposed on a fundamental design that saw birth as a three-seat commercial twin-float amphibian, the P-35 had an extraordinarily convoluted development history.

Its progenitor the SEV-3, conceived by Alexander P de Seversky and transformed into practicality by Alexander Kartveli, fully reflected the dramatic advances in aeronautical technology taking place in the early thirties, few aircraft of the day combining more of these innovatory developments. Rolled out in June 1933 the basic design soon demonstrated remarkable changeling properties, progressing to military basic trainer (SEV-3XAR), two-seat fighter (SEV-2XP) and even single-seat fighter (SEV-1XP), all without fundamental structural re-design.

In SEV-1XP form, as first flown in August 1935, it was winning contender in a US Army single-seat pursuit contest – effectively a straight competition between the Seversky fighter and the Curtiss Model 75 (see pages 82-83) – and recipient of an order for 77 production models with deliveries commencing as P-35s in May 1937. Offering a roomy, comfortable cockpit and pleasant handling characteristics, the P-35 was a well-designed and robust aircraft, but it was inadequate as a fighter, lacking the two most important attributes, adequate performance and firepower. It was extremely stable, too much so for its intended role, and it tended to fall away in a spin when approaching its official service ceiling. Inverted flight maneuvers, or outside loops, were prohibited, and the P-35 was already viewed as outmoded before the completion of deliveries in August 1938.

Despite the inherent shortcomings of the design, a more heavily-armed and marginally more powerful export version, the EP-1, was sold to Sweden, orders being placed for 120 aircraft. In the event only 60 were delivered, the remainder being requisitioned by the US government and 48 of these being sent to the Philippines as P-35As to see brief and inauspicious action at the beginning of the Pacific War, many of the US aircraft deployed in the Philippines being destroyed in a surprise attack by Japanese aircraft on the Luzon airfields on 8 December 1941.

SPECIFICATION: P-35

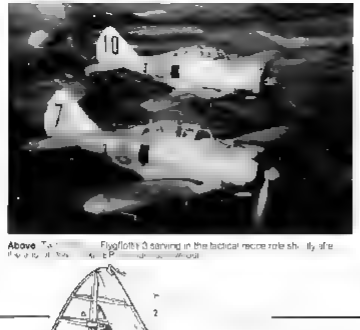
Power Plant: One Pratt & Whitney R1830-9 Twin Wasp 14-cylinder two-row radial air-cooled engine rated at 950 hp at 2,600 rpm for take-off and 850 hp at 6,000 ft (2,440 m). Three-bladed Hamilton Standard constant-speed metal propeller. Internal fuel capacity 168·5 Imp gal.

Performance: Max speed 281 mph (452 km/h) at 10,000 ft (3,050 m); max continuous cruise, 259 mph (417 km/h); range (max continuous cruise), 1,150 mls (1,850 km); rate of climb, 2,440 ft/min; 12·39 m/sec; time to 5,000 ft (1,525 m), 2·05 min; to 15,000 ft (4,570 m), 6·9 min; service ceiling 30,500 ft (9,325 m).

Weights: Empty equipped, 4,315 lb (1,957 kg); normal loaded, 5,598 lb (2,540 kg); max, 6,295 lb (2,855 kg).

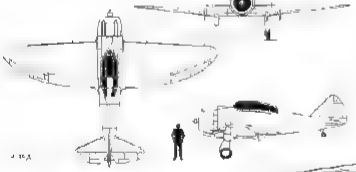
Dimensions: Span, 36 ft 0 in (10,97 m); length, 25 ft 2 in (7,67 m); height, 9 ft 1 in (2,77 m); wing area, 220 sq ft (20·44 m²).

Armament: One 0·30-in (7·62-mm) and one 0·50-in (12·7-mm) machine gun.

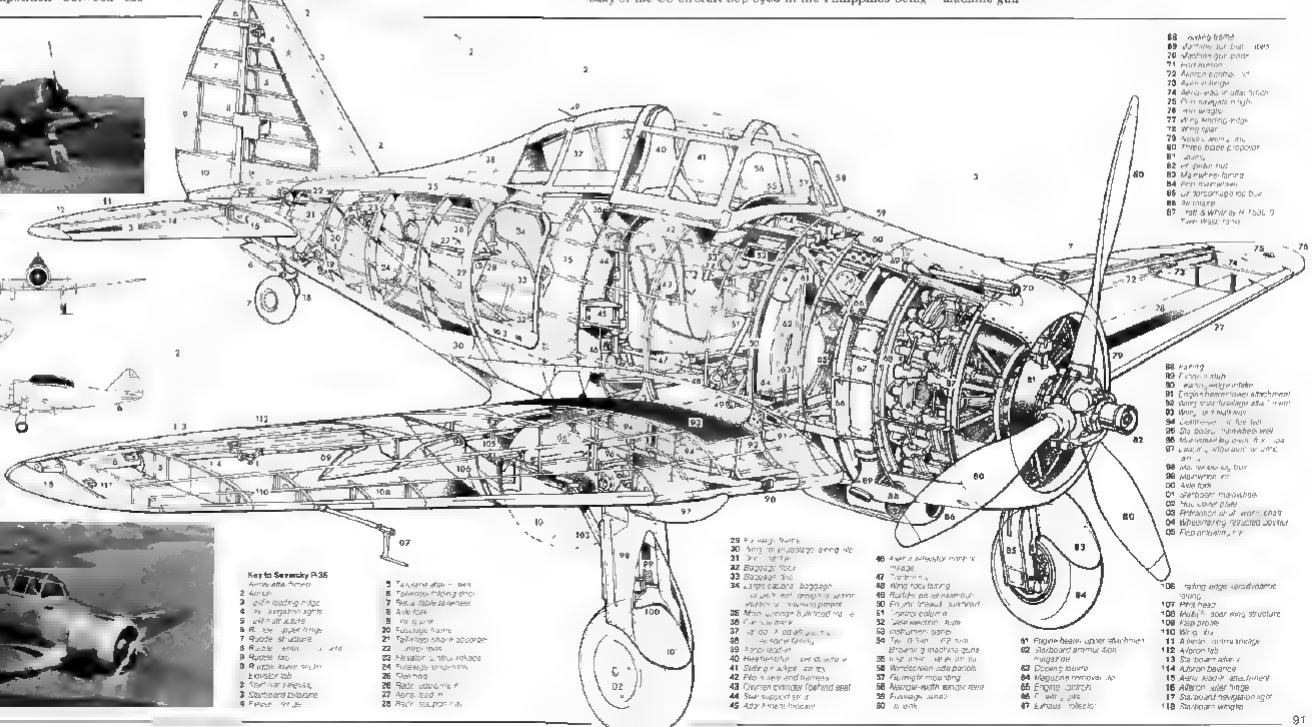


Above: [illegible] Flyoffs 3 serving in the tactical recce role [illegible]

Above: A Pan-American [illegible] 1942



Below: The P-35 [illegible] Curtiss [illegible] 75 [illegible] Pursuit [illegible] 1937 [illegible] 1938 [illegible] the P-35



Key to Seversky P-35

1 Aerial attachment
2 Aerial
3 Upper loading hinge
4 Navigation lights
5 Upper stabilizer
6 Rudder upper hinge
7 Rudder structure
8 Rudder [illegible]
9 Rudder [illegible]
10 Rudder lower hinge
11 Elevator tab
12 Starboard elevator
13 Starboard elevator balance
14 Elevator [illegible]
15 Tailplane attachment
16 Tailplane structure
17 Tailplane [illegible]
18 Rear spar
19 Tailplane [illegible]
20 Fuselage frame
21 Tailplane shock absorber
22 Jump seat
23 Ventilator [illegible]
24 Fuselage longeron
25 Floor rail
26 Rear [illegible]
27 Rear [illegible]
28 Rear support [illegible]
29 Fuselage frame
30 Wing to fuselage [illegible]
31 [illegible]
32 Baggage door
33 Baggage [illegible]
34 Large cabinet baggage [illegible]
35 Main wing to fuselage [illegible]
36 [illegible]
37 [illegible]
38 [illegible]
39 [illegible]
40 Heater [illegible]
41 Oil cooler [illegible]
42 Pilot's seat and harness
43 Oxygen cylinder behind seat
44 Seat support [illegible]
45 Fuselage [illegible]
46 [illegible]
47 [illegible]
48 Wing root fairing
49 Rudder pedal [illegible]
50 Engine bearer [illegible]
51 [illegible]
52 Steering column
53 Instrument panel
54 [illegible]
55 [illegible]
56 [illegible]
57 [illegible]
58 Windscreen [illegible]
59 Fuselage [illegible]
60 [illegible]
61 Flap-heavy upper attachment
62 Starboard ammunition magazine
63 Opening [illegible]
64 Magazine removal [illegible]
65 Engine [illegible]
66 [illegible]
67 Exhaust [illegible]
68 [illegible]
69 [illegible]
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85 [illegible]
86 [illegible]
87 Pratt & Whitney R1830-9 Twin Wasp engine
88 [illegible]
89 [illegible]
90 [illegible]
91 Engine bearer attachment
92 [illegible]
93 [illegible]
94 [illegible]
95 [illegible]
96 [illegible]
97 [illegible]
98 [illegible]
99 [illegible]
100 [illegible]
101 Starboard mainwheel
102 [illegible]
103 [illegible]
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107 [illegible]
108 [illegible]
109 [illegible]
110 [illegible]
111 [illegible]
112 Aileron [illegible]
113 Starboard aileron
114 Aileron balance
115 [illegible]
116 Aileron [illegible]
117 Starboard navigation light
118 Starboard wingtip

Hawker Hurricane (November 1935)

The logical outcome of a long line of single-seat fighting aircraft and a compromise in mating the requirements born of the new fighter monoplane era with traditional constructional methods, the Hurricane was the RAF's first combat aircraft capable of exceeding 300 mph (482 km h). During the early part of the burden of Britain's defence in the most significant aerial conflict ever fought, the Battle of Britain, the Hurricane complemented the Spitfire to a remarkable degree.

Designed by Sydney Camm and first flown on 6 November 1935, the Hurricane retained the classic tubular-metal cross-braced fabric-covered Warren-type structure, despite the all-metal trend towards the light metal stressed skin monocoque. This conservatism was, in full view of its contemporaries, [illegible] pilots with misgivings, resulting in design of a metal stressed-skin wing commencing before the prototype trials had begun.

An initial production contract was placed on 20 July 1936, the first aircraft flying on 12 October 1937, and the Hurricane proving itself very much a pilot's aeroplane. It was gentle and forgiving, control harmony was fairly good throughout the speed range, and aerobatics were pleasant and easy to execute. The controls hardened up with speed, although this was a characteristic that the Hurricane shared with most of its contemporaries, and it became somewhat stiff heavy in a dive. It was to be found inferior in [illegible] performance respects to its principal adversary in the Battle, the Bf109E, but it [illegible] a clear edge in low-altitude manoeuvrability, and in turning circle at all altitudes. Furthermore, as a result of the robust nature of its structure, it could absorb much battle damage and remain airborne.

Early in the Hurricane's career, the two-pitch propeller gave place to a constant speed [illegible]; the fabric-covered wing was soon replaced by that of all-metal stressed skin, and plywood armour was progressively introduced. Installation of the uprated Merlin XX engine resulted in the Hurricane II with tremendously expanded versatility, the Mk IID being an anti-armour version with 40-mm cannon, and production culminating in September 1944 with the universal armament wing" Mk IV. 12,780 Hurricanes have been built in the UK and a further 1,451 in Canada.

SPECIFICATION, Hurricane IIC

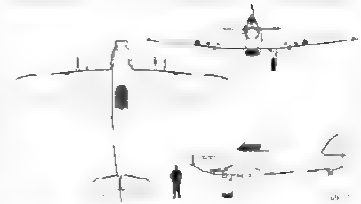
Power Plant: One Rolls-Royce Merlin XX 12-cylinder liquid-cooled vee engine rated at 1 280 hp at 3 000 rpm for take-off and 1 460 hp at 8 250 ft (1 905 m). Three-bladed Rotol constant-speed propeller. Internal fuel capacity, 97 Imp gal (441 l) and provision for two 45 Imp gal (205 l) drop tanks.

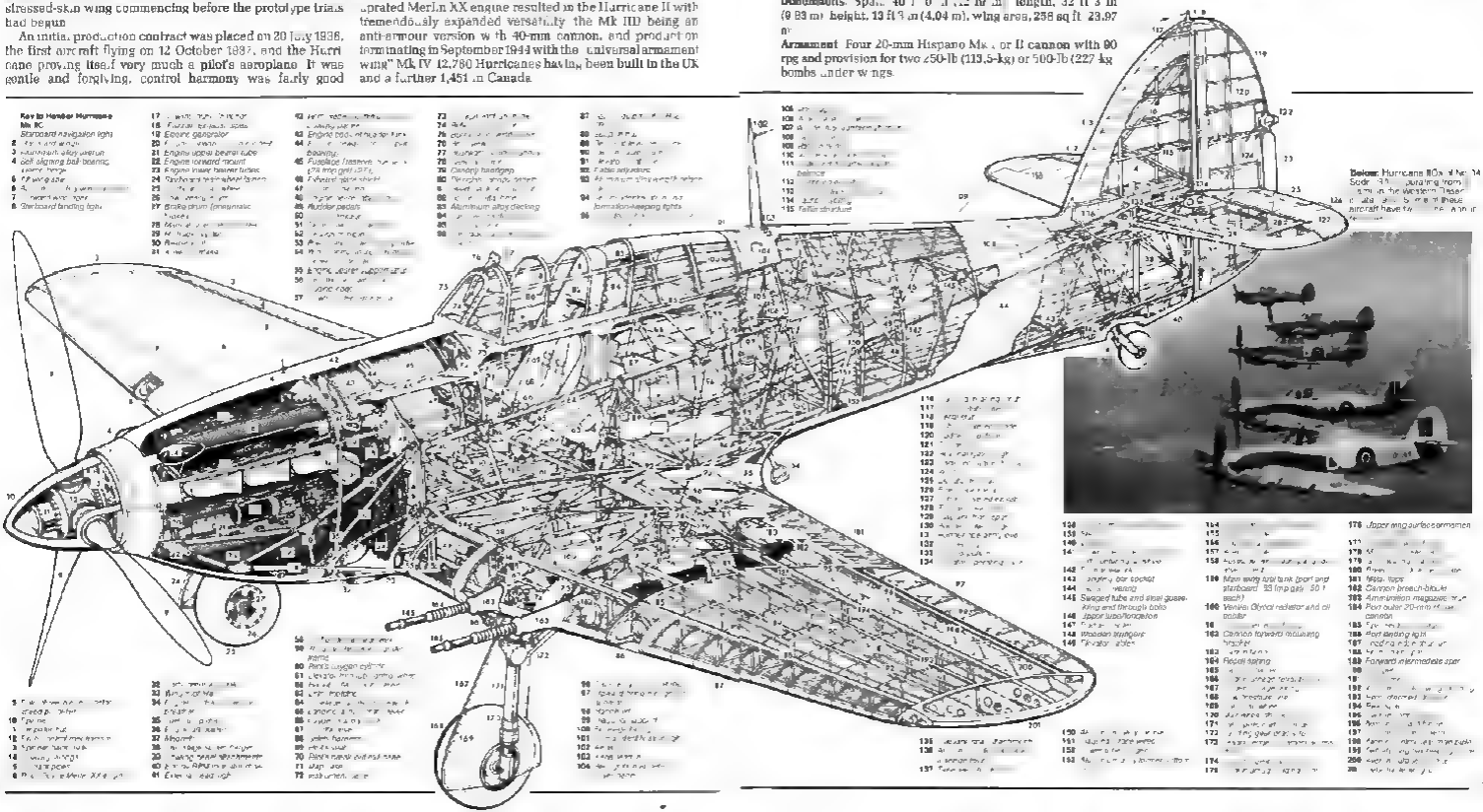
Performance: Max speed, 327 mph (526 km h) at 18,000 ft (5 485 m), (with tropical filter) 301 mph (484 km h); range, 460 mls (740 km) at 178 mph (286 km h) (with tropical filter), 426 mls (685 km) (with drop tanks). 920 mls (1 480 km); initial climb 2 750 ft min (13,9 m sec); time to 15 000 ft (4 575 m), 5 5 min, to 25 000 ft (7 620 m), 10 min; service ceiling 35 600 ft (10 [illegible] m).

Weights: empty [illegible] lb (2 [illegible] kg); normal loaded 7 544 lb (3 422 kg); max 8 044 lb (3 649 kg).

Dimensions: Span 40 ft 0 in (12 19 m); length, 32 ft 3 in (9 83 m); height, 13 ft 9 in (4,04 m), wing area, 258 sq ft (23,97 m²).

Armament: Four 20-mm Hispano Mk I or II cannon with 90 rpg and provision for two 250-lb (113,5-kg) or 500-lb (227 kg) bombs under wings.





Below: Hurricane IIDs of No. 34 Sqdn [illegible] operating from [illegible] on the Western Desert [illegible] aircraft have [illegible]

Fokker D XXI (February 1936)

The D XXI may be viewed as a compromise between the long accepted and the newly fashionable in fighter design. It retained Fokker's time-proven constructional recipe: a welded steel-tube fuselage and wooden wings, primarily fabric covered — and such passe features as a fixed undercarriage and two-pitch propeller. It incorporated, however, certain concessions to modernity, notably a cantilever low wing and also an enclosed cockpit.

If Dr Ing. Schatzk and his team were manifestly in their approach to fighter design by international standards already established in the mid-'thirties, and the D XXI was in consequence unimpressive, this reflected the unpretentious specification, formulated by the Air Division of the Royal Netherlands Army, that had resulted in a design of an Fokker. Furthermore, all-metal, stressed-skin monocoque structures were at the time beyond Fokker's capability. The specification placed emphasis on ease of maintenance in the field and simplicity of operation, and although retractable undercarriages had become vogue, the disadvantages that such incurred seemed, to the Fokker team, to outweigh gains at the performance levels sought: the reduced drag would have resulted in a three-four per cent speed gain and the increased weight would have reduced climb.

The prototype D XXI was flown on 27 February 1936, 36 being ordered for the home-based Army's Air Division, production acceptances commencing July 1938. The D XXI proved to possess somewhat unforgiving character: sides. Overly vigorous aft movement of the stick would result in the fighter rolling left and falling away in a spin, and an inadvertent flick roll at the top of a loop was almost inevitable if the rudder bar was even slightly off centre. The landing speed and glide angle were high, and there was a disconcerting tendency to drop a wing at the last moment, and a habit of ground-looping if the tailwheel was unlocked. Conversely, the D XXI had light controls, was extremely sturdy and provided a stable gun platform.

An export order (for seven) was obtained from Finland, where the licence manufacturer of 35 was subsequently undertaken, with the first flying in October 1938, and Denmark, too, licence-built the fighter, completing 10 after producing two as pattern aircraft. In 1940, after the Fokker fighters had given good service in the Soviet-Finnish conflict, as the D XXIs of the home-based Air Division were to do during the invasion of the Netherlands in May 1940, Finland reinstated D XXI production, building a further 55 with the R-1535 Twin Wasp engine, for which Fokker had previously adapted the basic airframe.

SPECIFICATION D XXI

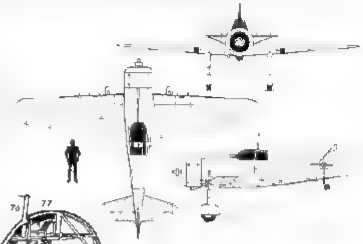
Power Plant: One Bristol Mercury VIII nine-cylinder radial air-cooled engine rated at 730 hp at 2,650 rpm for take-off and 825 hp at 13,000 ft (3,960 m). Three-blade two-pitch metal propeller. Internal fuel capacity, 77 Imp gal (350 l).

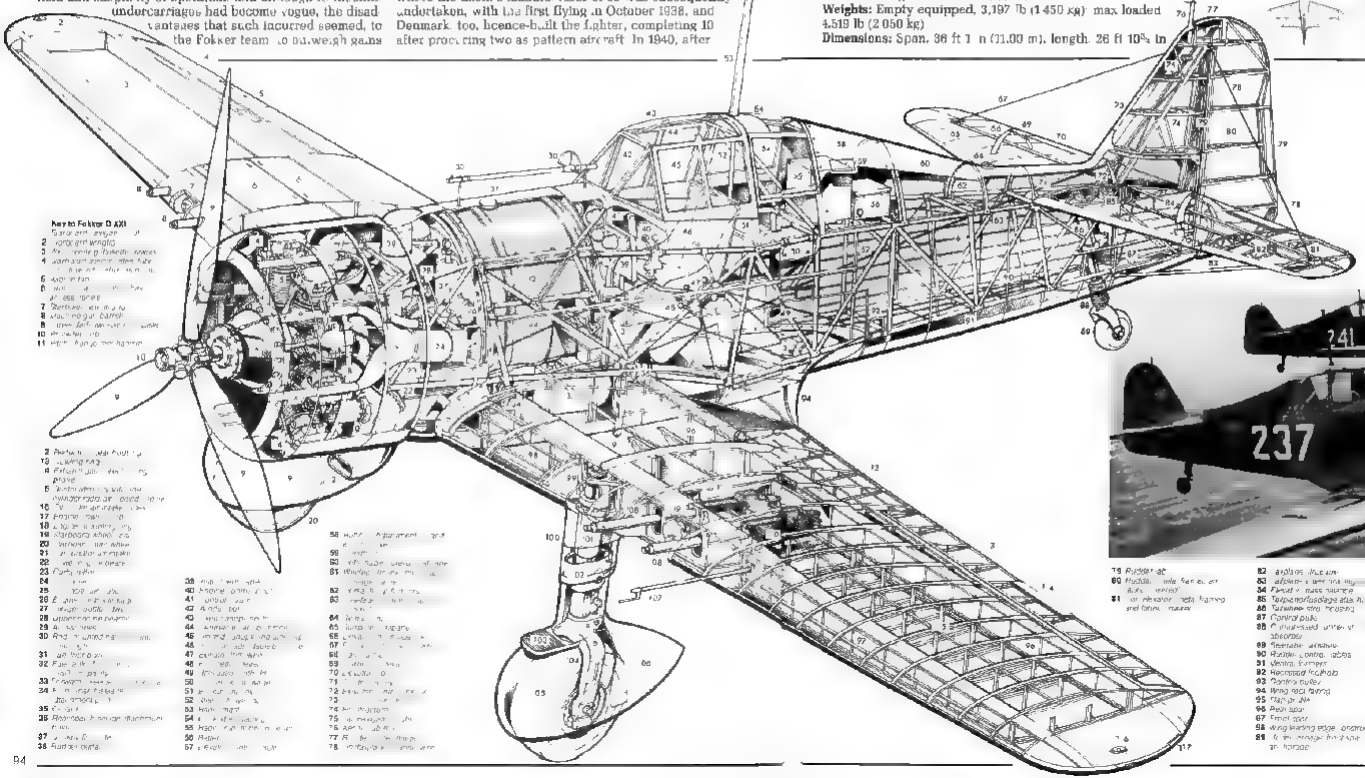
Performance: Max speed 286 mph (460 km/h) at 16,730 ft (5,100 m), cruise (66% power), 240 mph (386 km/h) (55% power), 235 mph (368 km/h), range (55% power), 590 mls (850 km), initial climb, 3,937 ft/min (20 m/sec), time to 6,560 ft (2,000 m) 2.3 min, to 9,840 ft (3,000 m) 4.05 min, service ceiling 36,090 ft (11,000 m).

Weights: Empty equipped, 3,197 lb (1,450 kg); max loaded 4,519 lb (2,050 kg).

Dimensions: Span, 36 ft 1 in (11.00 m), length, 26 ft 10⅝ in (8.20 m), height, 9 ft 8 in (2.95 m), wing area, 174.37 sq ft (16.20 m²).

Armament: Four 7.9-mm FN Browning M 36 machine guns with 300 rounds of ammunition for each gun.



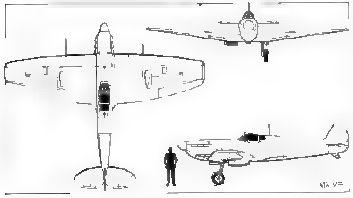


Key to Fokker D XXI

Below: D XXIs of the [illegible] in the LVA photographed during a new-duty patrol, principally by Dr G. de Haas, the mainstay of the Netherlands in WWII. The D XXI was sturdy and simple — the pilot's view [illegible]

Supermarine Spitfire (March 1936)

Occasionally a fighter appears that enjoys charisma attended by success in infancy and consolidating that success in maturity. Very rarely, such a fighter achieves a truly legendary status but the Spitfire was destined to be just such a rarity. It was to be more than just a highly successful fighter, however, for it was to be the material symbol of final victory to the British at a time when the nation's fortunes were at their nadir.



The success of the Spitfire was not fortuitous. It was both an inspired design and the distillation of past experience. Its sires included the S 6B, which, in 1931, had won the Schneider Trophy outright, and in no fighter was breeding more clearly discernible. With such a pedigree, nothing less than a true thoroughbred *could* have resulted when, late in 1934, Reginald J. Mitchell defined the new fighter, which was to fly as a prototype on 6 March 1936 and receive a production contract three months later.

Like the Bf 109 (see pages 84-87), flown 10 months earlier, the Spitfire employed state-of-the-art all-metal stressed-skin monocoque structural techniques and, similarly, it was the smallest practicable airframe that could be designed around a pilot, the chosen power plant and the specified armament. Mitchell's approach was perhaps more conservative than that of his German contemporaries in that he sought modest wing loadings whereas Messerschmitt and Lasser gambled on appreciably higher loadings with a sophisticated arrangement of leading-edge slots and slotted trailing-edge flaps.

The Bf 109 concept was the more advanced: it was to place the German fighter at a disadvantage to the Spitfire in agility, but it gave an edge in climbing, diving and in level speed below 20,000 ft (6,095 m). The respective advantages accruing from these differing philosophies were largely to cancel each other out, however, when the two fighters met as adversaries in the epic "Battle of Britain" which was to bring immortality to the Spitfire.

Flown on 14 May 1938, the production Spitfire I began to reach RAF squadrons in the following August and 19 squadrons had been equipped by the time that the new fighter was committed to the "Battle". From this point the basic fighter was to be subjected to the intensive development and incremental redesign resulting in three distinct generations, each closely linked with the available of more powerful engines, and when this gene... process had run its course, little remained unaltered. Perhaps surprisingly, the Spitfire, aesthetically one of the most elegant fighters ever to grace an airfield, lost little beauty through its three generations and was to remain throughout fundamentally Mitchell's original design.

continued on page 99 ▶

SPECIFICATION Spitfire IA

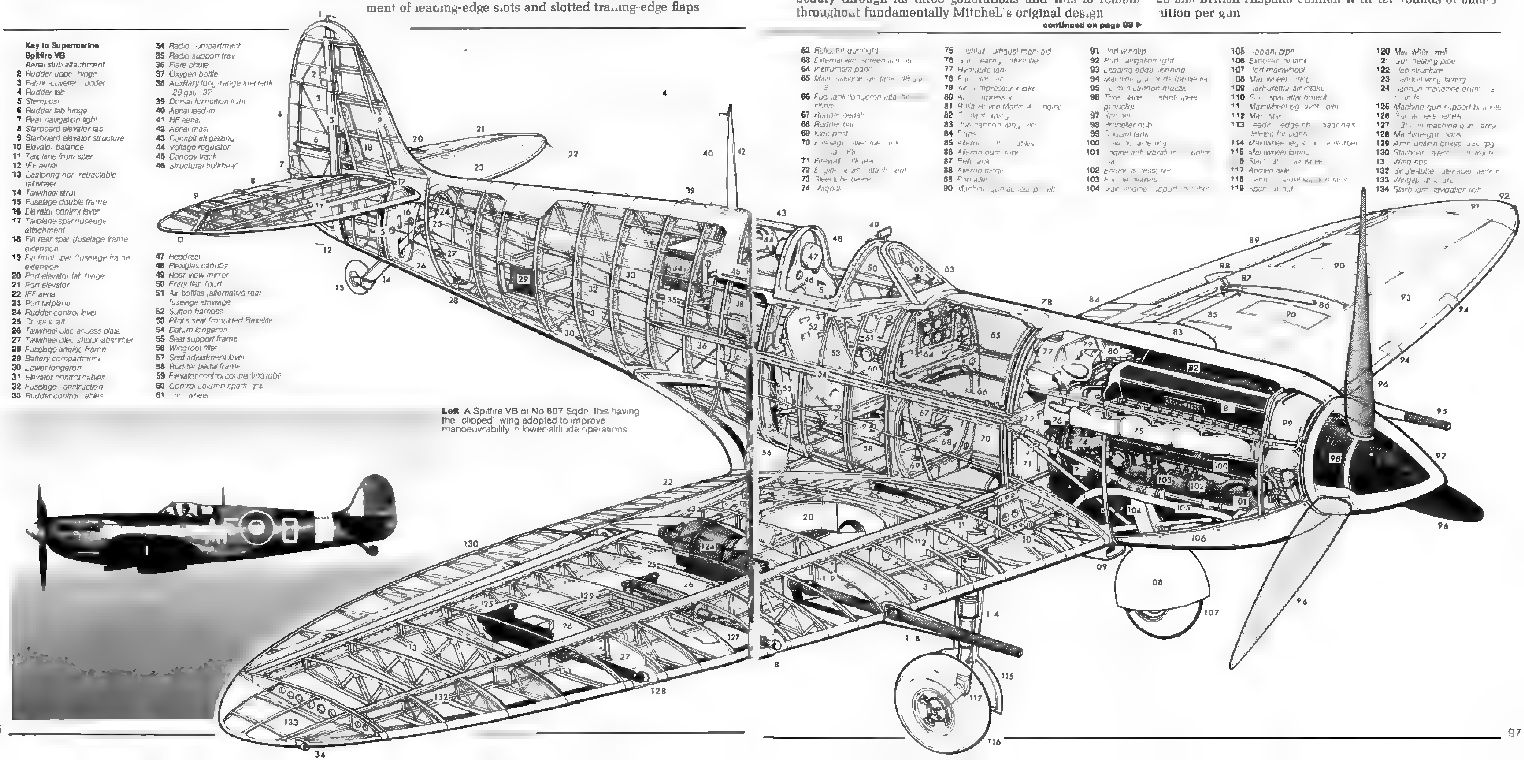
Power Plant: One Rolls-Royce Merlin II 12-cylinder vee liquid-cooled engine rated at 880 hp at 3,000 rpm for take-off and 1,030 hp at 16,250 ft (4,954 m). Three-bladed de Havilland two-pitch metal propeller. Internal fuel capacity: 84 Imp gal (382 l).

Performance: Max speed: 346 mph (557 km/h) at 15,000 ft (4,575 m); max cruise: 304 mph (489 km/h) at 15,000 ft (4,575 m); range: 415 mls (668 km) at max cruise, 630 mls (1,014 km) at 175 mph (282 km/h); climb to 15,000 ft (4,575 m): 6·85 min; service ceiling: 30,500 ft (9,295 m); endurance at maximum power: 43 min, maximum endurance: 3·6 hours.

Weights: Empty equipped: 4,517 lb (2,049 kg); normal loaded: 5,844 lb (2,651 kg).

Dimensions: Span: 36 ft 10 in (11,23 m); length: 29 ft 11 in (9,12 m); height: 12 ft 7¾ in (3,86 m); wing area: 242 sq ft (22·40 m²).

Armament: Eight 0·303-in (7·7 mm) Browning Mk II machine guns with 300 rounds of ammunition per gun. (Mk IB) Two 20-mm British Hispano cannon with 120 rounds of ammunition per gun.



Key to Supermarine Spitfire VB

1 Aerial stub attachment
2 Rudder upper hinge
3 Rudder trimmer actuator
4 Rudder tab
5 Starboard
6 Rudder tab hinge
7 Port navigation light
8 Starboard navigation light
9 Starboard elevator structure
10 Elevator balance
11 Tailplane front spar
12 HF aerial
13 Locking nut, retractable tailwheel
14 Tailwheel strut
15 Fuselage double frame
16 Elevator control lever
17 Tailplane spar/fuselage attachment
18 Tailplane rear fuselage frame extension
19 Fin front spar/fuselage frame extension
20 Port elevator tab hinge
21 Port elevator
22 IFF aerial
23 Port tailplane
24 Rudder control lever
25 Port tab
26 Tailwheel vertical oleo
27 Tailwheel oleo shock absorber
28 Fuselage whole frame
29 Battery compartment
30 Lower longeron
31 Elevator mainplane tube
32 Fuselage construction
33 Rudder control cables
34 Radio compartment
35 Radio support tray
36 Flare chute
37 Oxygen bottle
38 Auxiliary fuel tank (24 gal. 37)
39 Dorsal formation light
40 Aerial lead-in
41 HF aerial
42 Aerial mast
43 Cockpit air pipe
44 Voltage regulator
45 Control rod
46 Structural bulkhead
47 Headrest
48 Rear-view mirror
49 Rear view mirror
50 Rear flat plate
51 Air bottles (alternate rear fuselage stowage)
52 Supercharger
53 Pilot's seat (adjustable)
54 Datum longeron
55 Seat support frame
56 Windscreen rail
57 Seat adjustment lever
58 Rudder pedal frame
59 Fenestrated control rod (rudder)
60 Control column spar
61 [illegible]
62 Rudder gun mount
63 Cockpit floor
64 Port main gear
65 Main undercarriage [illegible]
66 Fuselage longeron [illegible]
67 Rudder pedal
68 Rudder foot
69 Kick panel
70 Fuselage [illegible]
71 Rudder [illegible]
72 [illegible]
73 Seat back [illegible]
74 Aileron
75 Wing [illegible]
76 Port wing [illegible]
77 Hydraulic line
78 [illegible]
79 [illegible]
80 [illegible]
81 [illegible]
82 [illegible]
83 [illegible]
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85 [illegible]
86 [illegible]
87 [illegible]
88 [illegible]
89 [illegible]
90 [illegible]
91 [illegible]
92 Port navigation light
93 Leading edge [illegible]
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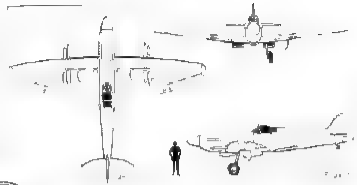
Left: A Spitfire VB of No 807 Sqdn, the having the clipped wing adopted to improve manoeuvrability in lower-altitude operations.

Supermarine Spitfire

next ▶

From August 1940, an improved sub-type, the Spitfire II with a Merlin XII engine and pilot armour, began to reach the squadrons, initiating the evolution that was to allow the Spitfire to retain its position among the best fighters available to any of the warring nations. Thirty of the 1,567 Mk Is built had been the initial recipients of the 'B' type wing in which four of the machine guns were supplanted by a pair of 20-mm cannon, and thus wing was to be applied to 170 of the 921 Mk IIs completed. The Mk II was superseded in turn by the Mk V, which built in larger numbers (6,487), than any variant, started life essentially as a Mk II with uprated Merlin 45 engine.

The two-speed, two stage supercharged Merlin 60 series launched the second-generation Spitfire, the first of which was the Mk IX, which basics by a Mk V airframe, was a Merlin 61 powered interim model introduced urgently to counter the Fw 190 (see pages 128-129), while the pressurized Mk VII and unpressurized Mk VIII intended to take full advantage of the new series engines were brought to fruition. The Mk IX made its



serviced, but in June 1942 no fewer than 5,646 being built, the Mk VII (140 built) and Mk VIII (1,658 built) following from September and the end of the year respectively.

Mating of the airframe with the Griffon engine produced a third and final Spitfire generation, and after the interim Mk XII (a Mk V adoption) the Mk XIV was built from the ground up for the new power plant, entering service January 1944 (957 being produced). Its direct successor was the Mk XVIII with lengthened fuselage and rear-view hood, the latter having been applied to late Mk XIVs, but evolution did not reach its apex until the appearance of the Mks 21 and 22 with a new extended wing, five-bladed propeller and other changes. The Mk 21 became operational in April 1945 (120 built), the Mk 22 (287 built) differing primarily in having the rear-view cockpit canopy, late examples featuring an enlarged tail.

A decade of Spitfire production came to its close in March 1948 with delivery of the last of 54 Mk 24s, which embodied revised fuel tankage. These aircraft brought the grand total of all types of Supermarine Spitfire built (excluding prototypes) to no less than 20,346.

SPECIFICATION: Spitfire F Mk 22

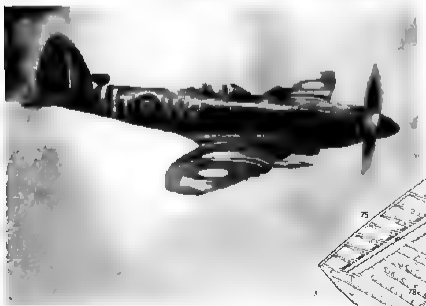
Power Plant: One Rolls-Royce Griffon 64 12-cylinder vee liquid-cooled engine rated at 1,520 hp at 2,750 rpm for take-off and 2,375 hp at 1,250 ft (380 m). Five-bladed Rotol constant-speed propeller. Internal fuel capacity 186 Imp gal (845 l), with provision for 90 Imp gal (409 l) drop tank.

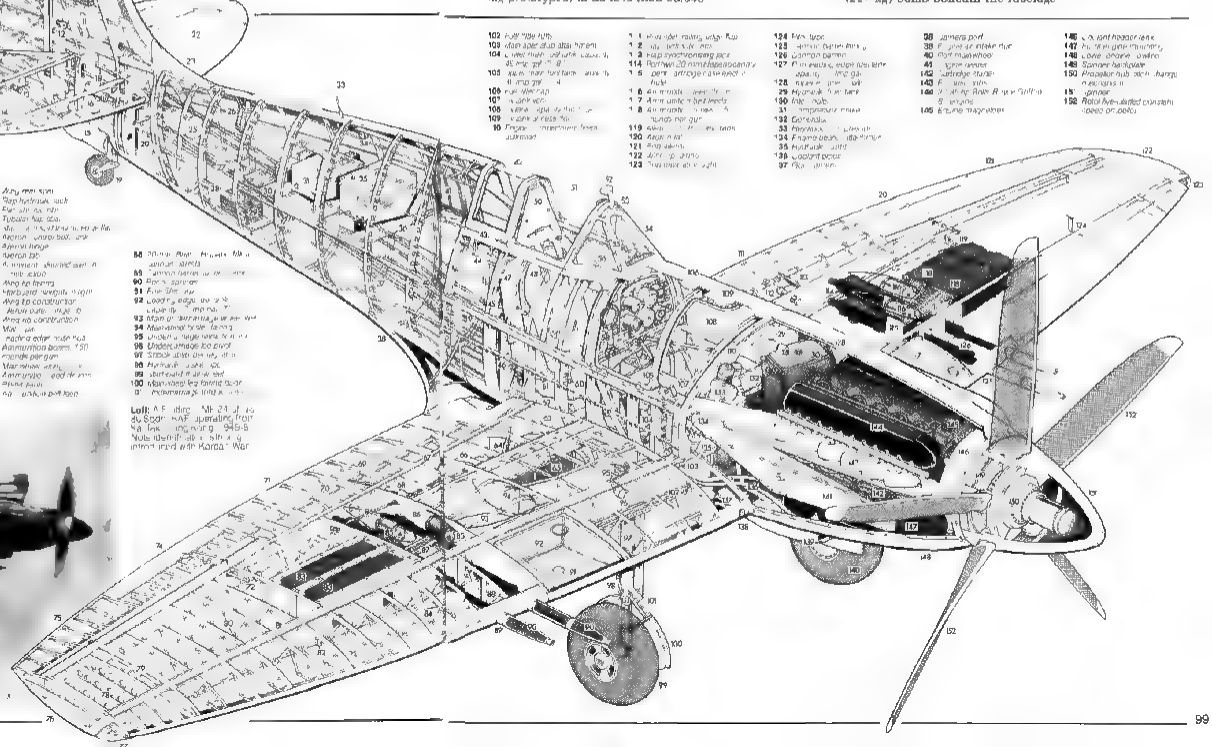
Performance: Max speed: 390 mph (628 km/h) at sea level, 450 mph (724 km/h) at 19,600 ft (5,975 m); average cruise 230-245 mph (370-394 km/h) at 20,000 ft (6,095 m); range (max internal fuel), 580 mls (933 km) (with drop tank), 965 mls (1,553 km); initial climb, 4,880 ft min (24.79 m/sec); service ceiling, 41,000 ft (13,105 m).

Weights: Empty equipped, 7,160 lb (3,247 kg); normal, 9,900 lb (4,490 kg); max, 11,290 lb (5,121 kg).

Dimensions: Span, 36 ft 11 in (11.25 m); length, 32 ft 11 in (10.04 m); height, 13 ft 6 in (4.12 m); wing area, 243.6 sq ft (22.63 m²).

Armament: Four 20-mm British Hispano Mk II cannon with 175 rpg inboard and 150 rpg outboard. Provision for one 250-lb (113.5-kg) bomb beneath each wing and a 500-lb (227 kg) bomb beneath the fuselage.





Key to Supermarine Spitfire 21

1 Starboard elevator construction
2 Elevator tab
3 Jettisonable spar
4 Aileron hinge rib
5 Fabric-covered aileron construction
6 Stringers
7 Aileron balance weight
8 Aileron spar
9 Aileron construction
10 Jettisonable weights
11 Aileron control spar
12 Aileron main rib
13 Tailplane front spar
14 Tailplane construction
15 Fuselage frame
16 Rear spar
17 Tailplane attachment arm
18 Tailplane control rods
19 Fuselage
20 Fuselage [illegible]
21 Port elevator
22 Port aileron
23 Fin root fairing
24 Tailplane leading edge
25 Rear fuselage
26 Gun-cartridge signal flare discharge
27 Aileron control rod
28 Aileron hinge
29 Fuselage spare weights
30 Battery
31 R 3067 radio receiver
32 Rear access door
33 Wireless
34 Hydraulic reservoir
35 [illegible]
36 Rear [illegible]
37 Fuselage frame and stringer construction
38 Wing root trailing edge fairing
39 Control cable run
40 Fuselage main longeron
41 Rear vertical stiffener
42 Canopy sliding
43 Spring-gear [illegible]
44 Voltage regulator
45 Fuselage frame frame
46 Seat support framework
47 Back armour
48 Pilot's seat
49 Seat mounting
50 Head armour
51 Rear view mirror
52 Windscreen framing
53 Bullet-proof windscreen
54 Reflector gunsight
55 Hinged side panel
56 Instrument panel
57 Control column
58 Canopy mounting
59 Hydraulic [illegible]
60 Seat adjustment [illegible]
61 Seat pan armour plate
62 Wing root fit
63 Radiator access door
64 Cockpit [illegible]
65 Control [illegible]
66 Port leading edge
67 Wing main spar
68 Rear fuselage
69 Fuselage [illegible]
70 Port [illegible]
71 [illegible]
72 Aerial lead-in
73 Aerial lead
74 Aerial [illegible]
75 [illegible]
76 Wing leading edge
77 Hydraulic [illegible]
78 Wing to [illegible]
79 Aerial [illegible]
80 Wing rib construction
81 Main spar
82 Leading edge [illegible]
83 Ammunition boxes (150 rounds per gun)
84 Main wheel [illegible]
85 Ammunition [illegible]
86 Wheel [illegible]
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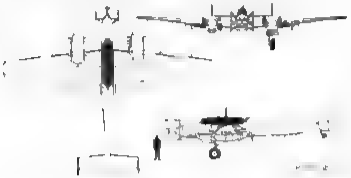
Left: A Spitfire Mk 24 of No 45 Squadron RAF, operating from Kai Tak, Hong Kong, 1948-5. Note identification stripes, worn during period of the Korean War.

Messerschmitt Bf 110 (May 1936)

The strategic fighter concept a warplane coupling high performance and heavy armament with endurance for deep penetration offensive sorties over enemy territory saw birth in WWI, but it was not until the second half of the thirties that it took really practicable form in the shape of the Bf 110. Referred to as a *Zerstörer*, a term borrowed from naval parlance the Bf 110 flew on 12 May 1936. Its initial large-scale production sub-type the Bf 110C entering service with the Luftwaffe from January 1939 onward.



A supremely elegant warplane for which a formidable reputation was assiduously fostered by German propagandists the Bf 110 proved an abysmal failure when committed to the "Battle of Britain". It was not the indifferent warplane that this debacle suggested however but the victim of an inadequate understanding of the limitations of the strategic fighter concept and its incorrect deployment as a consequence. No designer however talented could create a large and heavy twin-engined fighter capable of competing in agility with single-engined contemporaries.

Once the limitations of the Bf 110 were appreciated it was to serve throughout the remainder of WWII with distinction in a variety of diurnal and nocturnal roles. An eminently soundly designed warplane with pleasant handling characteristics, a very good performance and surprisingly manoeuvrable for its size and twin-engined configuration the Bf 110 was the backbone of German night defence production, ending March 1945 totalled some 6,050. Its basic design proved amenable to engine changes and application of equipment beyond any envisaged by its designers.

SPECIFICATION Bf 110C-4c R3

Power Plant: Two Daimler-Benz DB 605B-1 12-cylinder inverted-vee liquid-cooled engines each rated at 1 475 hp at 2,800 rpm for take-off and 1 355 hp at 16 700 ft (5 700 m). Three-blade VDM controllable-pitch propellers. Internal fuel capacity 278 Imp gal (1 270 l) with provision for two 66 Imp gal (300 l) drop tanks.

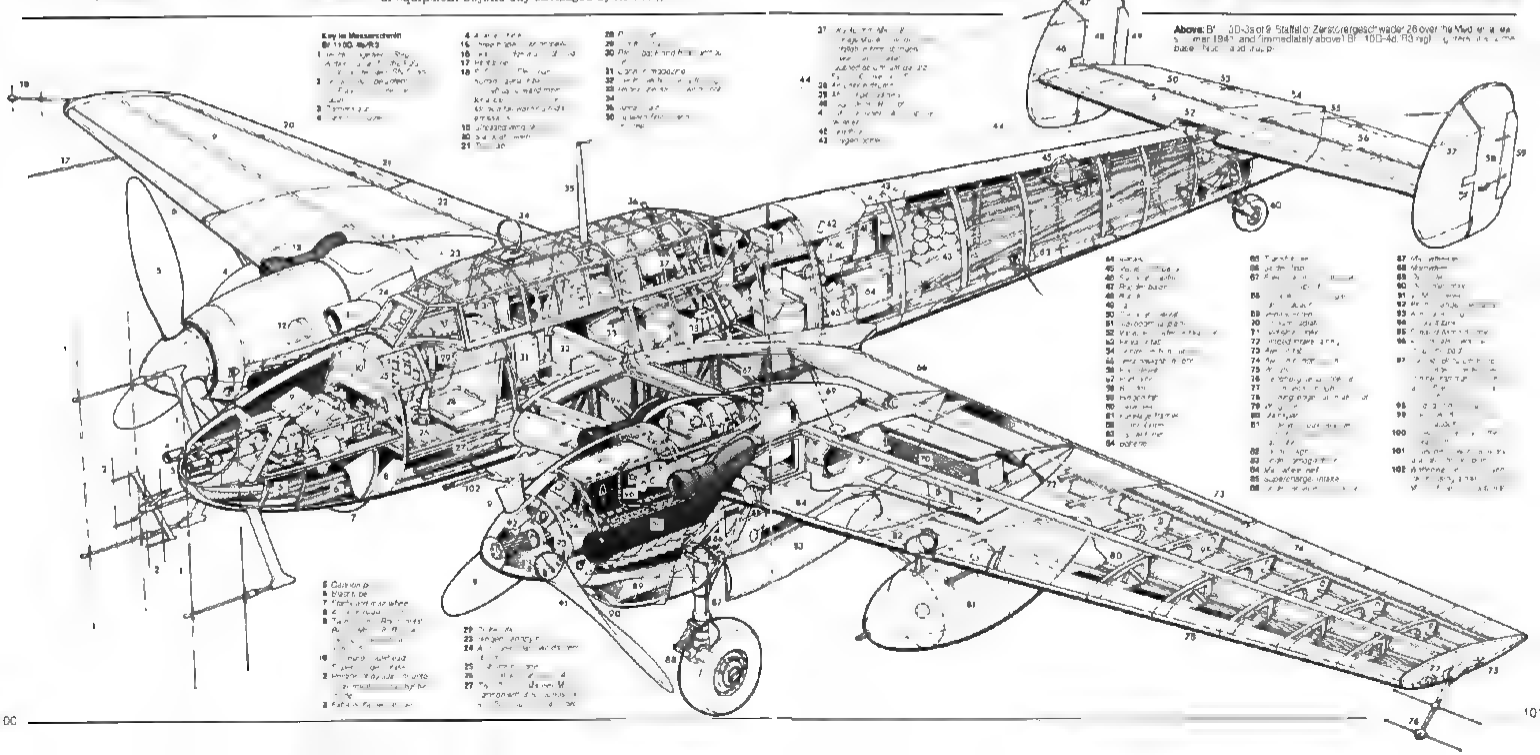
Performance: Max speed 311 mph (500 km/h) at sea level, 342 mph (550 km/h) at 22,900 ft (6 980 m); max continuous cruise, 317 mph (510 km/h) at 19 685 ft (6 000 m); max range (internal fuel), 560 mls (900 km), (with two drop tanks) 808 mls (1 300 km); max climb rate 2,170 ft/min (11 m/sec); service ceiling 26 250 ft (8 000 m).

Weights: Empty equipped, 11 230 lb (5 094 kg); normal loaded 20,701 lb (9 390 kg); max. 21 799 lb (9 888 kg).

Dimensions: Span, 53 ft 3¼ in (16.25 m); length (excluding radar antennae), 39 ft 6¼ in (12.07 m), (including antennae) 42 ft 9¾ in (13.05 m); height 13 ft 8½ in (4.18 m); wing area, 413.33 sq ft (38.40 m²).

Armament: Two 30-mm Rheinmetall Borsig MK 108 cannon with 135 rpg and two 20-mm Mauser MG 151 cannon with 300 (port) and 350 (starboard) rounds, plus one 7.9-mm MG 81Z twin machine gun with 800 rounds, or twin 20-mm MG 151 or MG FF cannon in schrägen Musik installation.

Above: Bf 110-3s of 9./Staffel/Zerstörergeschwader 26 over the Med[illegible] [illegible] mar 1941 and immediately above Bf 110-4d/R3 rigg[illegible] [illegible] base [illegible] and dive [illegible]



Nakajima Ki.27 (October 1936)

Above: [illegible]

Configurationally similar to the Fokker D XX (see pages 94-95) flown seven and a half months earlier but of very much more advanced structural concept, the Ki.27 was indisputably an inspired design, but its very success performed a disservice for Japan in that it overly influenced subsequent fighter development policy, generating complacency which resulted in insufficient attention being given to fighter development trends elsewhere.

Imperial Army pilots were encouraged to compare their dexterity in dogfighting with the skilled use of the bamboo Shinai by masters of the ancient martial art of Kendo. Thus, qualities of manoeuvre were accorded pre-eminence in a fighter, and a somewhat bigoted attitude was adopted towards other attributes if they could be emphasized only at some expense to agility. The Ki.27, however, was a supremely successful compromise between the demands of those traditionalists and those of the visionaries in respect of speed and climb.

Designed by Prof Hideo Itokawa and Yasumi Koyama and first flown on 15 October 1936, the Ki.27 represented the smallest practicable airframe that could be designed around a Kotobuki (Congratulation) radial engine. Emulating the Imperial Navy's A5M (see pages 78-79), it was of all-metal flush-riveted stressed skin semi-monocoque construction, and fitted with hydraulically-operated split flaps. Extraordinarily light and possessing superlative agility, the Ki.27 was ordered into production as the Army Type 97 Fighter, making its operational debut over China in April 1938. Lacking in firepower, armour and fuel tank protection, and what fighters of the period possessed these desirable features in combination—the Ki.27 was without doubt the fastest fighter in the Orient and bore favourable comparison with fighters being produced contemporaneously by the most technologically advanced western countries.

At an early production stage, the initial Ki.27ko gave place to the Ki.27otsu featuring minor cockpit changes and when the type was phased out by the parent company late 1940 production transferred to the Mansyu Hikoki Seizo K.K. (Manchurian Aeroplane Manufacturing Co Ltd) at Harbin in Japan's puppet state of Manchukuo, northeast China. There it continued for a further 18 months, finally bringing the total of this type manufactured to 3,398 aircraft.

SPECIFICATION: Ki.27otsu

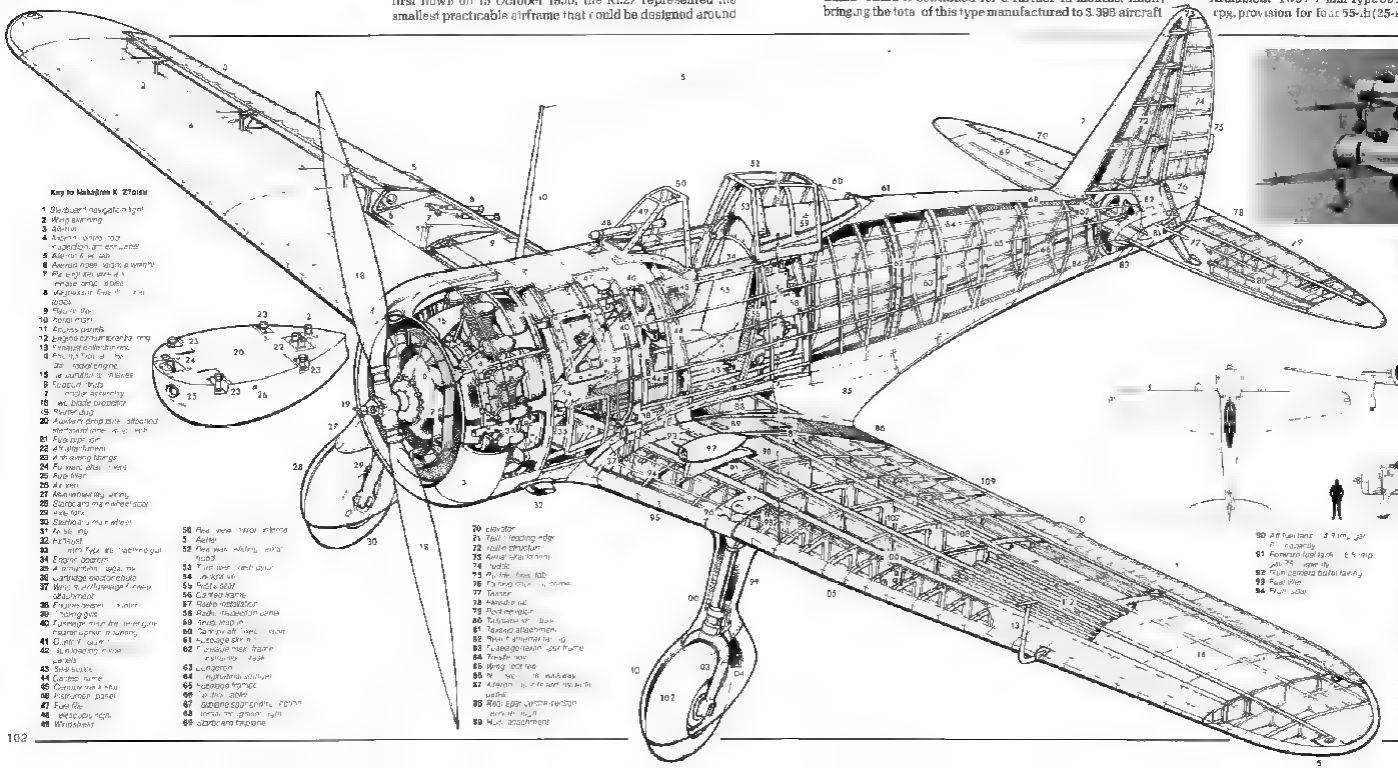
Power Plant: One Nakajima Ha-Ietsu (Kotobuki) nine-cylinder radial air-cooled engine rated at 710 hp at 2,600 rpm for take-off and 780 hp at 9,515 ft (2,900 m). Two-bladed Sumitomo PE metal two-pitch (ground adjustable) propeller. Internal fuel capacity, 72.6 Imp gal (330 l), with provision for two 28.6 Imp gal (130 l) auxiliary tanks.

Performance: Max speed, 265 mph (427 km/h) at 9,280 ft (1,000 m), 276 mph (445 km/h) at 6,560 ft (2,000 m), 292 mph (470 km/h) at 11,480 ft (3,500 m); max continuous cruise, 217 mph (350 km/h) at 11,480 ft (3,500 m); range, internal fuel, 390 mls (630 km), with auxiliary tanks, 683 mls (1,100 km); time to 3,280 ft (1,000 m), 1.16 min; to 9,840 ft (3,000 m), 2.98 min; service ceiling, 40,190 ft (12,250 m).

Weights: Empty equipped, 2,447 lb (1,110 kg); normal loaded, 3,410 lb (1,547 kg); max, 3,946 lb (1,790 kg).

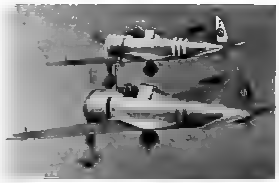
Dimensions: Span, 37 ft 1¼ in (11.31 m); length, 24 ft 8½ in (7.53 m); height, 10 ft 8 in (3.26 m); wing area, 199.78 sq ft (18.56 m²).

Armament: Two 7.7 mm Type 89 machine guns with 500 rpg; provision for four 55-lb (25-kg) bombs under wing.

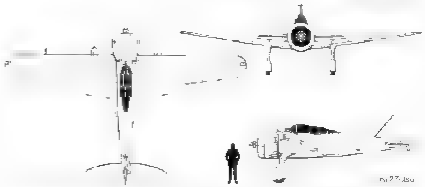


Key to Nakajima Ki.27otsu

1 Starboard navigation light
2 Wing skinning
3 Aileron
4 Aileron control rod
5 Aileron hinge
6 Aileron nose balance plate
7 Rib and stringer construction
8 Magnesium fuselage skin
9 Fuselage rib
10 Horizontal stabilizer
11 Engine cowling
12 Engine cylinder fins
13 Exhaust collector ring
14 Fuselage skin panels
15 Nakajima Ha-Ietsu (Kotobuki) engine
16 Ventilation louvres
17 Engine mounting
18 Engine assembly
19 Wing root fairing
20 Aileron drop back attachment
21 Fuselage longeron
22 Anti-glare panel
23 Anti-glare panel
24 Fuselage stringer
25 Fuselage frame
26 Air intake
27 Mainwheel leg strut
28 Starboard mainwheel door
29 Hub fairing
30 Starboard mainwheel
31 Tailplane
32 Fin root
33 Rear fuselage stringer
34 Engine bearers
35 Anti-glare panel
36 Cartridge ejector chute
37 Wing to fuselage fairing attachment
38 Engine bearer
39 Starting gas
40 Fuselage rear fairing, upper rear upper fairing
41 Control cable
42 Fuselage rear fairing, lower
43 Shell ejector
44 Control cable
45 Control rod
46 Fuselage panel
47 Fuel line
48 Windscreen
49 Rear view mirror support
50 Rear view mirror
51 Aerial
52 Rear view mirror, mounting bracket
53 Turn bar, left pylon
54 Pylon
55 Rudder seat
56 Control frame
57 Rudder operating
58 Rudder operating cable
59 Wing root rib
60 Control cable
61 Fuselage skin
62 Fuselage rear fairing, lower
63 Longeron
64 Hydraulic actuator
65 Fuselage frame
66 Rudder post
67 Rudder seat control
68 Rudder control
69 Rudder hinge
70 Elevator
71 Tailplane leading edge
72 Rudder structure
73 Aerial attachment
74 Rudder
75 Rudder hinge
76 Control cable
77 Tailplane
78 Elevator
79 Rudder
80 Tailplane root
81 Tailplane attachment
82 Rear fuselage
83 Fuselage rear fairing
84 Tailplane
85 Wing root rib
86 Aileron hinge
87 Aileron control rod
88 Rear spar centre section
89 Wing root rib
90 Aft fuel tank, 8.8 Imp gal capacity
91 Aileron trailing edge
92 Gun camera bulge
93 Fuel line
94 Rear spar
95 Wing rib
96 Anti-corrosion film
97 Landing gear strut
98 Ventilation spar attachment
99 Mainwheel leg, upper
100 Mainwheel leg, lower
101 Strut
102 Mainwheel
103 Axle
104 Brake cable
105 Wheel hub
106 Mainwheel
107 Wing rib
108 Aileron control rod
109 Flaps
110 Aileron
111 Port aileron
112 Stringer
113 Port flap
114 Wing skinning
115 Port navigation light



Above: Ki.27otsu fighters [illegible]



Junkers Ju 88 (December 1936)

There can be little doubt that fortuity influences the success or failure of many aircraft: there can be no doubt whatsoever that the success of what was to rank as arguably the most outstanding long-range heavy fighter and night fighter of WWII was purely fortuitous. This, the Ju 88, had been conceived solely as a *Schnellbomber*—a high-speed bomber in the design of which performance was uncompromised by the needs of alternative roles. In the event this strictly dedicated design was to evolve as perhaps the most versatile warplane ever produced: it was to excel in all the roles of a very wide repertoire and in none more so than that of fighter.

Intended to meet a *Schnellbomber* requirement formulated in the spring of 1935, and designed by W H Evers and A Gassner both having gained experience in light metal stressed-skin constructional techniques in the USA the Ju 88 owed nothing to any preceding design from the Junkers drawing boards. The first prototype the Ju 88 V1, flew on 21 December 1936 immediately demonstrating a quantum performance advance. Its potential in the heavy fighter or *Zerstörer*, role was apparent before the bomber attained service the Ju 88 V7 being modified for *Zerstörer* trials in the summer of 1939. The possibilities of the Ju 88 for the nocturnal intercept task, too were foreseen early in WWII but with all priority assigned to the bomber, fighter capability was of little more than academic interest.

A rudimentary *Zerstörer* adaptation of the bomber, the Ju 88C-2, did appear in 1940, however, and in the autumn of 1941 the Ju 88C-4 built from the ground up as a heavy fighter began to enter service. The first *Zerstörer* manufactured in really large numbers was to be the Ju 88C-6, and late in 1942, this began to play a part in the nocturnal defence of Germany. Changing operational requirements produced successive sub types, the liquid-cooled Jumo engines of the C series giving place to BMW radials in early G-series aircraft, which, with enlarged tail surfaces appeared in the spring of 1944. 700-800 subsequently being manufactured in parallel with the C-series of which about 3,200 were delivered to the Luftwaffe.

An outstanding pilot's aeroplane the Ju 88 demanded some degree of skill in handling offering excellent performance and a high level of agility for an aeroplane of its size and weight.

SPECIFICATION: Ju 88G-7b

Power Plant: Two Junkers Jumo 213E 12-cylinder inverted vee liquid-cooled engines each rated at 1,750 hp at 3,200 rpm for take-off and 1,320 hp at 31,990 ft (9 750 m). Three-bladed VS 19 constant speed wooden propellers. Internal fuel capacity, 704 Imp gal (3 200 l). Provision for one 198 Imp gal (900 l) drop tank.

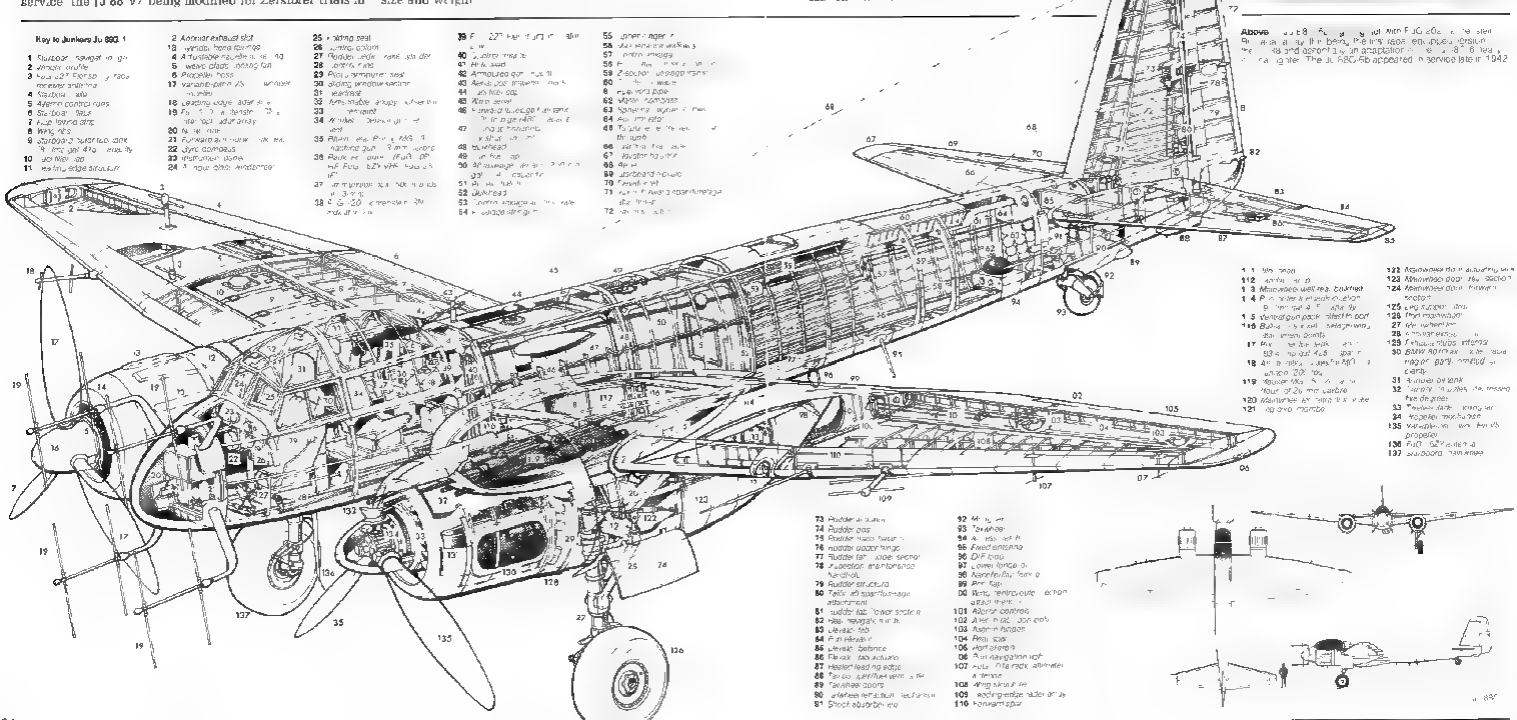
Performance: Max speed 270 mph (435 km/h) at sea lev 383 mph (584 km/h) at 33 465 ft (10 200 m), (with MW 50 water-methanol injection) 389 mph (626 km/h) or (without flame dampers) 402 mph (647 km/h) at 29 855 ft (9 100 m) endurance including one hour at emergency power with MW 50 boost 3·72 hrs initial climb, 1 855 ft min (9 4 m sec) time to 32 315 ft (9 850 m), 28 4 min.

Weights: Normal loaded, 28 900 lb (13 110 kg), max 32,350 lb (14 674 kg).

Dimensions: Span, 65 ft 10½ in (20,08 m) length, 51 ft 0¼ in (15,55 m), height, 15 ft 11 in (4,85 m) wing area 586·6 sq ft (54,50 m²).

Armament: Two fixed forward-firing 20-mm MG 151 cannon with 200 rounds of ammunition for each cannon, and one flexibly-mounted aft-firing 13 mm MG 131 machine gun with 500 rounds of ammunition.

Above: Ju 88 [illegible] with Fuselage [illegible] being [illegible] equipment version [illegible] and adaptation [illegible] The Ju 88C-6b appeared in service late in 1942



Bloch 152 (May 1937)

Probably the least auspicious chapter in the story of French fighter development was that provided by the production derivatives of the Bloch 150. These burly, menacing fighters were sturdily built and capable of sustaining considerable battle damage. They were viceless, they possessed excellent dive characteristics and their agility, if perhaps lacking in vivacity and somewhat demanding on pilot muscle, was superior to that of the Messerschmitt Bf 109 against which they were to be pitted in combat. Conversely, they were too large and heavy for the power available to them and, in consequence, lacked the acceleration, level speed and climb rate necessary to compete effectively over France in the summer of 1940, these deficiencies being compounded by manifestly inadequate ammunition capacity.

Bodevilled from birth by problems associated with their fundamental design, these fighters stemmed from the Bloch 150, which, designed by Maurice Roussel, was conceived as a private venture. Almost a year elapsed between completion of the Bloch 150 prototype and its successful first flight on 4 May 1937, and then a complete structural redesign was found necessary in order to render series production practical. The re-structured and aerodynamically refined Bloch 151 flew on 18 August 1938, the first production example being taken on charge by the Armée de l'Air on 7 March 1939, but this sub-type had already been overtaken by the Bloch 152, first flown on 15 December 1938, embodying changes intended to reduce drag and improve low-speed behaviour. In consequence, production of the Bloch 151 was restricted to 144 aircraft which were declared by the Armée de l'Air unsuited for first-line duties, although the exigencies of 1940 were to dictate their use in combat.

The Bloch 151 and 152 were externally barely distinguishable, the latter differing, apart from the GR 14N engine variant installed, in having a revised wing, which, while retaining the same torsion box, possessed 5.6 per cent more area. Teething problems were numerous, not least of these being achievement of satisfactory engine cooling with acceptable drag. Seven Groupes de Chasse were operating Bloch 151s and 152s on 10 May 1940, and of the 363 of the latter taken on charge to that time, only 80 embodied all the modifications that were at that time considered necessary to render them fully operational.

SPECIFICATION: Bloch 152

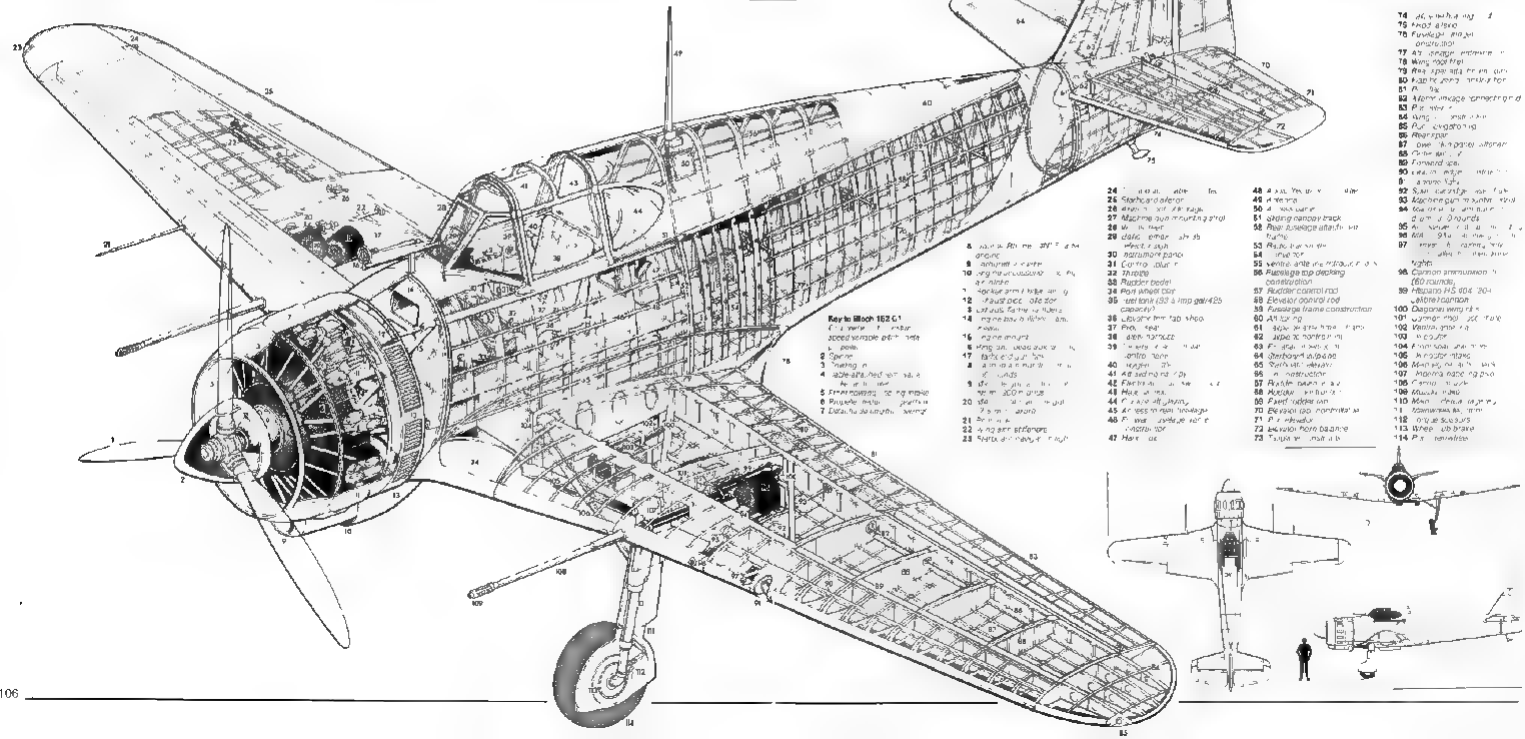
Power Plant: One Gnôme-Rhône 14 N 49 14-cylinder two-row radial, air-cooled engine rated at 1,180 hp at 2,400 rpm for take-off and 1,070 hp at 12,140 ft (3,700 m). Three-blade metal variable-pitch Chauvière 371 propeller. Internal fuel capacity 93.5 Imp gal (425 l).

Performance: Max speed, 310 mph (500 km/h) at 18,045 ft (5,500 m); max continuous cruise, 261 mph (420 km/h); economic cruise, 211 mph (340 km/h); max range, 360 mls (580 km); time to 26,245 ft (8,000 m), 14.3 min; service ceiling, 32,810 ft (10,000 m).

Weights: Empty equipped, 5,966 lb (2,706 kg); normal loaded, 5,966 lb (2,706 kg).

Dimensions: Span, 34 ft 8½ in (10.57 m); length, 29 ft 10¾ in (9.11 m); height (tail up), 11 ft 1¼ in (3.64 m); wing area, 185.58 sq ft (18.17 m²).

Armament: Two 20-mm Hispano-Suiza HS 404 cannon with 60 rpg and two 7.5-mm MAC 1934 machine guns with 300 or 500 rpg.



Grumman F4F Wildcat (September 1937)

USA

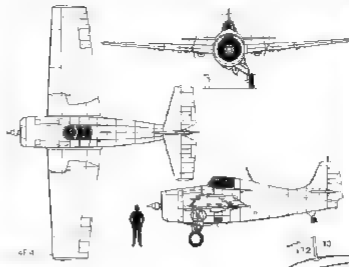
The design of any fighter must perforce involve a measure of compromise between conflicting requirements and that of a shipboard fighter more than most, a balance having to be struck between combat demands and operational venue dictates. When the Grumman F4F first appeared on carrier decks it represented what was almost certainly the best compromise achievable at the time between aeronautical and nautical requirements in a fighter monoplane.

Clearly showing the descent from the F3F (see pages 80-81) in its corpulence, the F4F lacked any pretensions to elegance. Designed to an outline specification drawn up by the US Navy late in 1935, the prototype, the XF4F-2, flew on 2 September 1937 being ordered into production two years later, in August 1939 as the F4F-3, soon to be emotively dubbed Wildcat. The F4F-3 began to enter US Navy service late 1940, being preceded into service by an export equivalent which, built against French contracts, joined the Royal Navy in the previous summer as Martlet I.

Whereas both the F4F-3 and Martlet I had fixed wings their successors, the F4F-4 and Martlet II, incorporated an ingenious method of wing folding in which the mainplanes pivoted around the mainspar. The first folding wing Martlet IIs were deployed operationally by the Royal Navy in September 1941, and F4F-4s had entered US Navy service by April 1942, serving in strength from the carriers Yorktown, Enterprise and Hornet at the Battle of Midway, June 1942.

The F4F possessed an extremely good rate of climb, an excellent patrol range, superb ditching characteristics and the sturdiness necessary for intensive carrier operations. More stable to fly and therefore heavier to manoeuvre than many of its shore-based contemporaries, it nevertheless had a small turning circle and a good roll rate. Its stalling behaviour was innocuous, but operation of the undercarriage handcrank tended to result in "roller coaster" climb-outs and acceptable spinning characteristics were not to be achieved until the advent of the definitive (FM-2) production model.

Production was eventually entrusted to Eastern Motors, who built 5 460 as FM-1s and FM-2s to bring the grand total of fighters of this series built to 7 815 aircraft, of which more than 920 went to the Royal Navy, that service eventually also adopting the name Wildcat for the aircraft.



SPECIFICATION: F4F-4

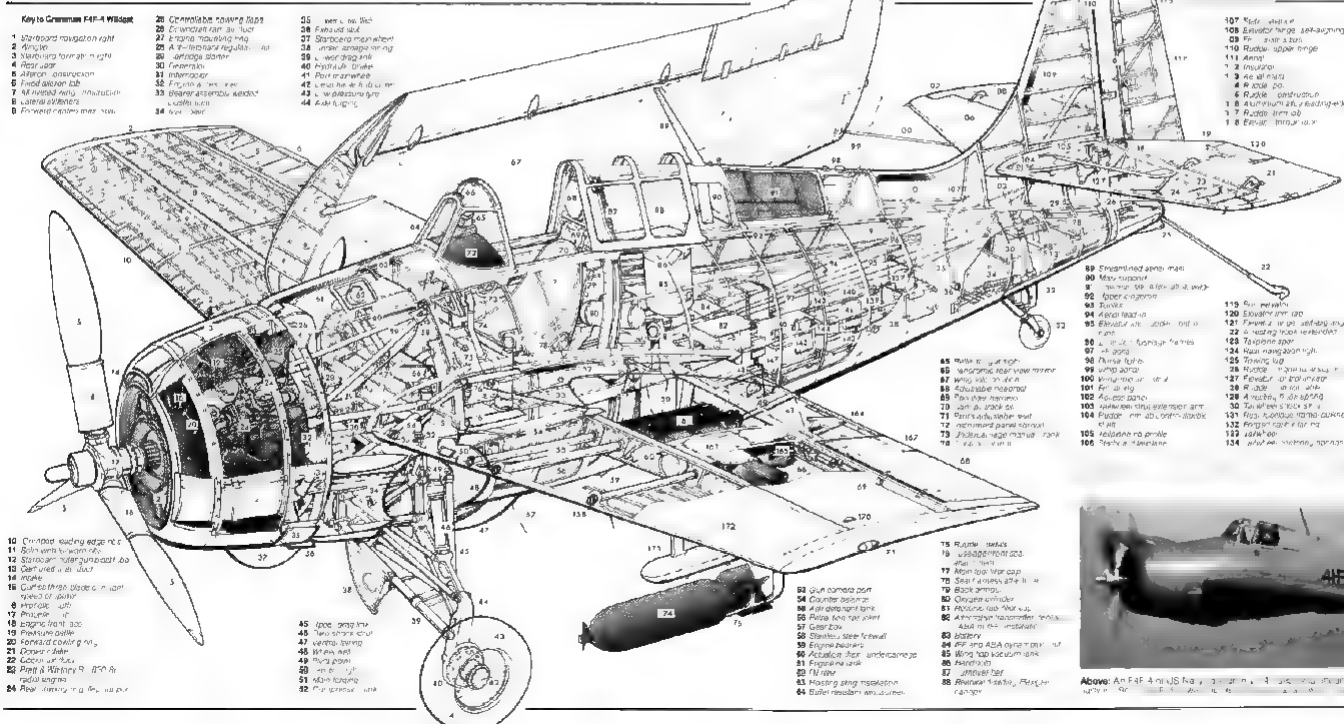
Power Plant: One Pratt & Whitney R-1830-86 Twin Wasp 14-cylinder two-row radial air-cooled engine rated at 1 200 hp at 2,800 rpm for take-off and 1,135 hp at 3 400 ft (1035 m). Three-blade Curtiss Electric constant-speed propeller. Internal fuel capacity 120 Imp gal (545 l), with provision for two 48 4 Imp gal (220 l) drop tanks.

Performance: Max speed, 274 mph (441 km/h) at sea level, 320 mph (515 km/h) at 18 800 ft (5 730 m), max range cruise 161 mph (259 km/h) at 5,000 ft (1 525 m), max range (internal fuel), 830 mls (1 335 km) (with drop tanks), 1,275 mls (2 050 km), initial climb 1 950 ft/min (9.9 m/sec), time to 10,000 ft (3 050 m), 5 6 min, to 20,000 ft (6 100 m) 22 4 min, service ceiling 34,000 ft (10 360 m).

Weights: Empty equipped 5,895 lb (2 674 kg), normal loaded 7,975 lb (3 617 kg), max, 8 762 lb (3 974 kg).

Dimensions: Span, 38 ft 0 in (11,58 m), length, 28 1, 0 in (8 65 m), height 11 ft 4 in (3,44 m), wing area 260 sq ft (24,15 m²).

Armament Six 0·50-in (12 7-mm) Colt-Browning M-2 machine guns with 240 rpg



Key to Grumman F4F-4 Wildcat

1 Starboard navigation light
2 Wing tip
3 Port wing navigation light
4 Rear spar
5 Aileron construction
6 Fixed aileron tab
7 Port folded wing construction
8 Lateral stiffeners
9 Forward folding mainspar

10 Corrugated leading edge ribs
11 Spar web to boom rivets
12 Stainless steel gun port tab
13 Centre-section gun port tab
14 Intake
15 Curtiss three-blade constant-speed propeller
16 Propeller hub
17 Engine front bay
18 Pressure bulkhead
19 Forward cowling
20 Cowling latch
21 Cowling flap
22 Pratt & Whitney R-1830-86 radial engine
24 Rear firewall

25 Retractable cowling flaps
26 Extension flap actuator
27 Engine mounting ring
28 A-frame engine support
29 Aerofoil section
30 Firewall
31 Intercooler
32 Engine accessories
33 Bearer assembly section
34 Nose spar

35 Port oil tank
36 Forward tank
37 Starboard main wheel
38 Under carriage leg
39 Leg drag link
40 Hydraulic brake
41 Port main wheel
42 Leg hinge fitting
43 Leg retraction jack
44 Axle fairing

45 Spee. brake jack
46 Two spark plug
47 Ventilating
48 Wheel well
49 Fuel pipe
50 Oil cooler
51 Main fairing
52 Oil cooler duct

53 Gun camera port
54 Counter balance
55 Oil delayed tank
56 Relay fire rail plate
57 Gear box
58 Stainless steel firewall
59 Engine bearers
60 Accessible fuel underscarriage
61 Engine fire tank
62 Oil tank
63 Heating gas insulation
64 Bullet resistant accumulator

65 Rudder trim tab
66 Vertical rear view mirror
67 Wing root fairing
68 Adjustable footrest
69 Rear view mirror
70 Jack pivot bracket
71 Pilot's adjustable seat
72 Instrument panel support
73 Rudder edge metal tank
74 Fuselage fuel tank

75 Rudder pedals
76 Undercarriage actuating jack
77 Main spar top flat cap
78 Seat frames and fittings
79 Back armour
80 Oxygen cylinder
81 Pressure cap filler cap
82 Atmospheric temperature sensing element
83 Battery
84 RF and ABA aerial mast
85 Wing cap vacuum tank
86 Handhold
87 Jettisonable
88 Rear fuselage fuselage fairing

89 Streamlined aerial mast
90 Mast support
91 Rear fuselage fuselage fairing
92 Spar diagonal
93 Bulkhead
94 Aerial leads
95 Elevator actuating rod
96 Elevator fairing
97 Jack
98 Rear lights
99 Wing aerial
100 Wing root fairing
101 Fin aerial
102 Aerial base
103 Tailplane rear spar arm
104 Rudder trim tab control stalk
105 Tailplane rib profile
106 Tailplane fairing

107 Rudder fairing
108 Elevator hinge self-aligning
109 Fin fairing
110 Rudder upper hinge
111 Aerial
112 Insulator
113 Aerial mast
114 Axle jack
115 Rudder construction
116 Aluminium alloy leading edge
117 Rudder trim tab
118 Elevator trim actuator

119 Fin metalling
120 Elevator trim tab
121 Fairing fin to tailplane
122 Adjusting trim handwheel
123 Tailplane spar
124 Main hang point lugs
125 Towing lug
126 Rudder
127 Elevator
128 Rudder
129 Tailwheel lock stop
130 Rear fuselage frame outlines
131 Rear fuselage
132 Rear fuselage
133 Tailwheel
134 Tailwheel locking spring

135 Aerial lead-in through bulkhead
136 Lifting tube
137 Remote compass transmitter
138 Tailwheel lock cable
139 Aerial
140 Section fuselage stringers
141 ZB searchlight
142 Transmitter
143 Elevator actuating
144 Aerial
145 Radio
146 Receiver
147 Radio
148 Radio
149 Fin
150 Rear
151 Fuselage
152 Wing hinge
153 Main undercarriage
154 Shock
155 Inboard gun
156 Dashboard
157 Wing
158 Outboard gun port
159 ZB searchlight
160 Head
161 Bullet
162 Outboard
163 ATA
164 Hub
165 Outboard
166 Aerial
167 Aerial
168 Port
169 Aerial
170 Aerial
171 Wing
172 Wing
173 Aerial
174 Starboard
175 Tailplane

Above: An F4F-4 of US Navy [illegible]

Macchi C.200 Saetta (December 1937)

Above [illegible] C.200s of the 8° squadriglia, 6° Gruppo, flying over [illegible] Italy, all converted to the C.202

The rate of fighter evolution in each country was, in the [illegible] dispersion-power plant development. The successful creation in Britain, France and Germany of a series of high-powered low-drag liquid-cooled engines had a profound effect on fighter design in those countries, but the tardiness of the Italian aero engine [illegible] power plant placed Italian fighter designers at a distinct disadvantage when developing their first generation of all-metal, stressed-skin, cantilever monoplanes. One of these new-generation fighters was the C.200 Saetta (Lightning) designed by Ing Mario Castoldi.

First flown on 24 December 1937, the C.200 revealed little of its distinguished pedigree of aerodynamically superior racing floatplanes. Its contours were essentially ungainly owing to the necessity of using a bulky drag-evoking radial engine in combination with a humped fuselage profile resulting from emphasis on pilot vision. Aesthetic appeal apart, the C.200 was a soundly conceived, innately robust fighter, the first production examples of which were completed in July 1939. It offered excellent handling and excellent response in all flight regimes. Its beautifully harmonised controls were finger-light, its climb-and-dive performance was outstanding, and it provided a stable gun platform. But the C.200 was lacking in level speed and firepower.

Production of C.200s finally totalled 1,153, but only 156 were on strength when Italy declared war, 10 June 1940. With the 241st C.200, the unpopular cockpit canopy was discarded. The basic design was adapted for Dunlop Rubber Company, spawned the excellent C.202 Folgore and C.205 Veltro.

SPECIFICATION: C.200 Saetta

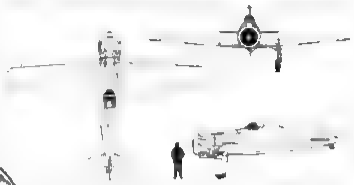
Power Plant: One Fiat A.74 RC.38 14-cylinder two-row radial air-cooled engine rated at 870 hp at 2,520 rpm for take-off and 840 hp at 12,465 ft (3,800 m). Three-bladed Piaggio P.1001 constant-speed propeller. Internal fuel capacity, 68 Imp gal (313 l) plus 18 Imp gal (83 l) internal overload tank and provision for 33 Imp gal (150 l) auxiliary tank.

Performance: (At 5,070 lb (2,300 kg) Max speed, 312 mph (503 km/h) at 14,765 ft (4,500 m); range (standard internal fuel), 354 mls (570 km) at 289 mph (465 km/h) at 19,685 ft (6,000 m), (with overload fuel and auxiliary tank), 540 mls (870 km); time to 3,280 ft (1,000 m), 1·05 min, to 16,405 ft (5,000 m), 5·85 min; ceiling, 29,200 ft (8,900 m).

Weights: Empty equipped, 4,541 lb (2,060 kg); normal loaded, 5,597 lb (2,538 kg).

Dimensions: Span, 34 ft 8½ in (10·50 m); length, 26 ft 10½ in (8·18 m); wing area, 180·94 sq ft (16·81 m²).

Armament: Two 12·7 mm SAFAT machine guns with 370 rpg, and provision for two 110-lb (50-kg), 220-lb (100-kg) or 352-lb (160-kg) bombs under wings.



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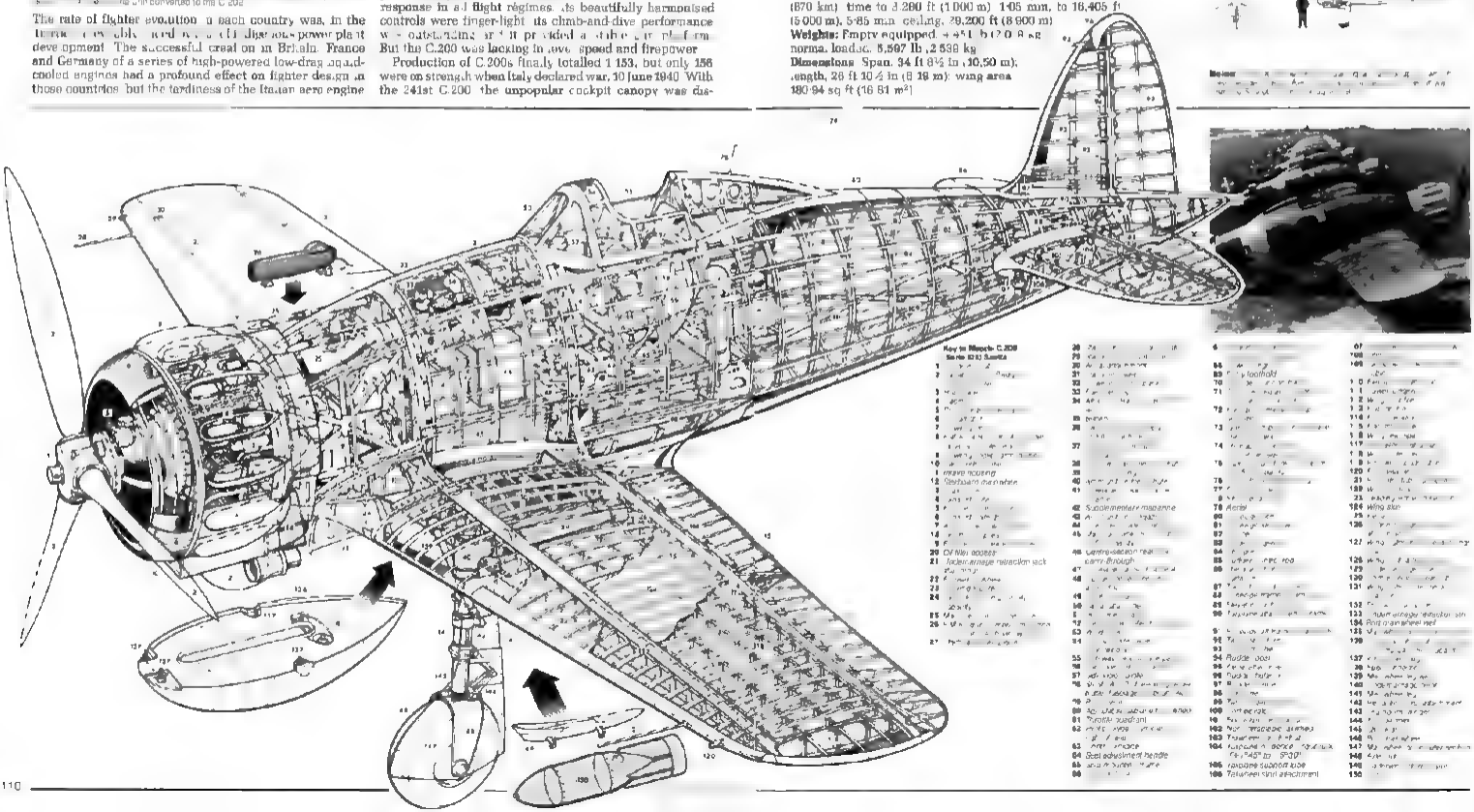

Key to Macchi C.200 Saetta

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4 [illegible]
5 [illegible]
6 [illegible]
7 [illegible]
8 [illegible]
9 [illegible]
10 [illegible]
11 Engine housing
12 Starboard mainplate
13 [illegible]
14 [illegible]
15 [illegible]
16 [illegible]
17 [illegible]
18 [illegible]
19 Oil filler access
20 Oil filler access
21 Understrange retraction jack
22 [illegible]
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39 [illegible]
40 [illegible]
41 [illegible]
42 Supplementary magazine
43 [illegible]
44 [illegible]
45 [illegible]
46 Centre-section rear spar through
47 [illegible]
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59 [illegible]
60 [illegible]
61 Throttle quadrant
62 [illegible]
63 [illegible]
64 Seat adjustment handle
65 [illegible]
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67 [illegible]
68 [illegible]
69 [illegible]
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71 [illegible]
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78 Aerial
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89 [illegible]
90 [illegible]
91 [illegible]
92 [illegible]
93 [illegible]
94 Rudder pedal
95 [illegible]
96 [illegible]
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99 [illegible]
100 [illegible]
101 [illegible]
102 [illegible]
103 [illegible]
104 [illegible]
105 [illegible]
106 Tailwheel spring attachment
107 [illegible]
108 [illegible]
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112 [illegible]
113 [illegible]
114 [illegible]
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117 [illegible]
118 [illegible]
119 [illegible]
120 [illegible]
121 [illegible]
122 [illegible]
123 [illegible]
124 Wing stub
125 [illegible]
126 [illegible]
127 [illegible]
128 [illegible]
129 [illegible]
130 [illegible]
131 [illegible]
132 [illegible]
133 Port strange retraction strut
134 Port main wheel well
135 [illegible]
136 [illegible]
137 [illegible]
138 [illegible]
139 [illegible]
140 [illegible]
141 [illegible]
142 [illegible]
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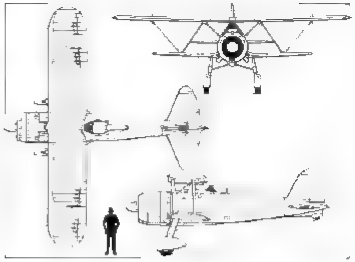
150 [illegible]

Fiat CR.42 Falco (May 1938)

Possessing the dubious distinction of having been both the last single-seat fighter of biplane configuration manufactured and the last to see extensive active service, the CR.42 Falco (Falcon) brought to a close the distinguished line of fighters created by Celestino Rosatelli. Extremely light on the controls, universally viewed as a delight to fly and superbly agile, the CR.42 carried the fighting biplane to its development apex, but had the misfortune to be conceived at a time when the biplane had already been eclipsed by the monoplane as the standard international fighter configuration.

Featuring the distinctive Warren truss interplane bracing that was the unmistakable hallmark of the Rosatelli fighters, the CR.42 first flew on 23 May 1938 and was already conceptually obsolete. Nevertheless, deliveries to the Regia Aeronautica began in April 1939; export orders were obtained from Belgium, Hungary and Sweden and production was to continue into 1943, a total of 1,781 CR.42s being delivered. It fought virtually throughout WWII, and curiously, it fought against the Luftwaffe (with the Aeronautica Militare Belge alongside the Luftwaffe (with the Regia Aeronautica) and with the Luftwaffe itself, singing the swan song of the fighting biplane while so doing.

Above: A Regia operator [illegible] thirsting from [illegible]



SPECIFICATION, CR.42 Falco

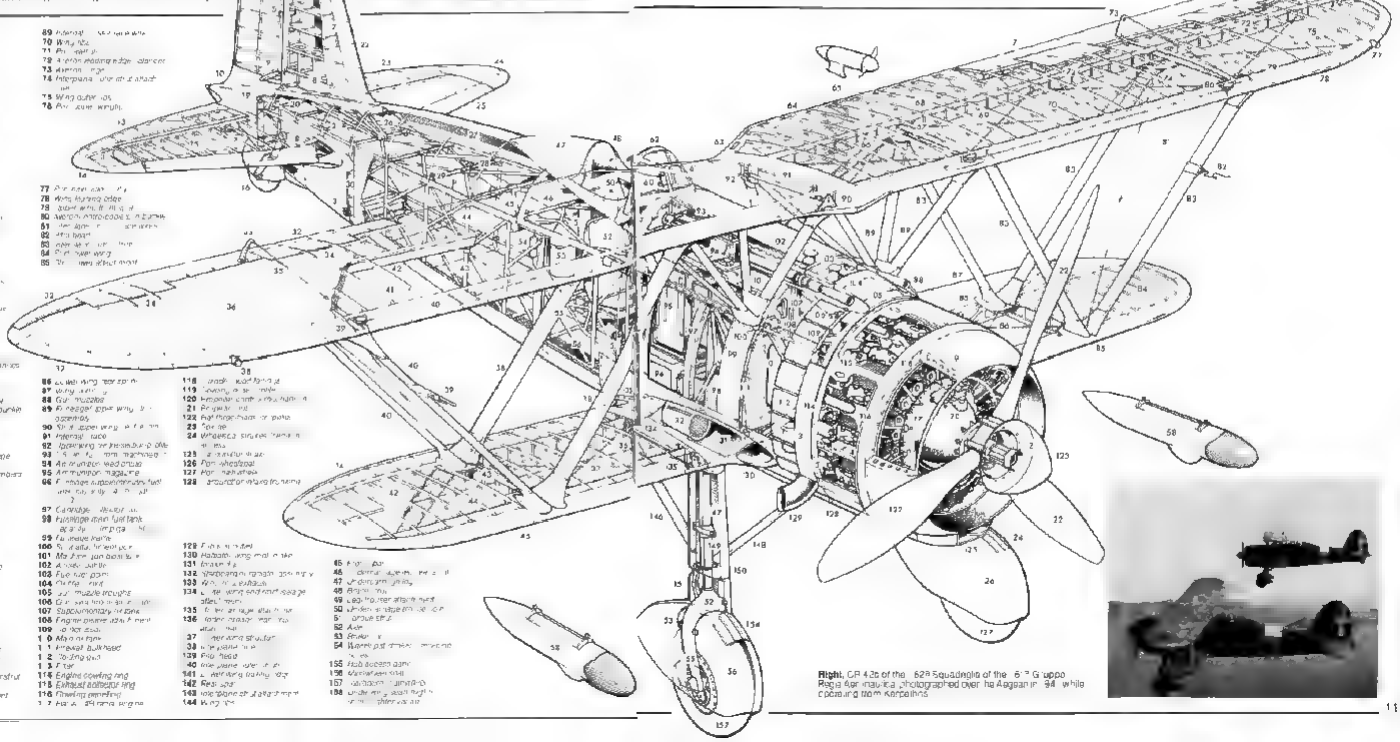
Power Plant: One Fiat A.74 RC.38 14-cylinder two-row radial air-cooled engine rated at 858 hp at 2,500 rpm (for three minutes) for take-off and 840 hp at 12,465 ft (3 800 m). Three-bladed variable-pitch Fiat 3D 41 1 propeller. Internal fuel capacity: 101 Imp gal (460 l)

Performance: Max speed: 212 mph (342 km/h) at sea level, 247 mph (397 km/h) at 9,840 ft (3 000 m); 267 mph (430 km/h) at 16 405 ft (5 000 m); climb to 9 280 ft (1 000 m): 1 4 min, to 9 840 ft (3 000 m): 4 25 min, to 16,405 ft (5 000 m): 7 39 min; service ceiling 33 465 ft (10 200 m); range, 481 m.s (775 km) at 238 mph (380 km/h) at 18,045 ft (5 500 m)

Weights: Empty equipped: 3 829 lb (1 782 kg); normal loaded, 5 059 lb (2 295 kg).

Dimensions: Span: 31 ft 9⅞ in (9,70 m), length: 27 ft 1⅜ in (8 27 m), height: 11 ft 9½ in (3.59 m), wing area, 241 11 sq ft (22 40 m²)

Armament: Two 12 7 mm SAFAT machine guns with 400 rpg.



Key to Fiat CR.42 Falco

1 Rudder [illegible]
2 Rudder [illegible]
3 Rudder [illegible]
4 Rudder post
5 Rudder [illegible]
6 Tailplane structure
7 Tailplane [illegible]
8 Tailplane [illegible]
9 Rudder [illegible]
10 Fairing
11 Tail navigation light
12 Elevator [illegible]
13 Starboard elevator
14 Elevator hinges
15 Tailplane structure
16 Fin [illegible]
17 Upper fin/rudder post
18 Rudder [illegible]
19 Rudder [illegible]
20 Fuselage [illegible]
21 [illegible]
22 [illegible]
23 [illegible]
24 Fairing [illegible]
25 [illegible]
26 Tail [illegible]
27 Fuselage [illegible]
28 Fuselage [illegible]
29 Fuselage upper frame
30 Fuselage frame stringers
31 [illegible]
32 [illegible]
33 Aerial [illegible]
34 Aileron trailing edge balances
35 Aileron [illegible]
36 Wing [illegible]
37 Starboard upper wing
38 Starboard [illegible]
39 Aileron control tube/turnbuckle
40 Aileron control [illegible]
41 Wing ribs
42 Wing [illegible]
43 Fuselage frameworks
44 Rudder control [illegible]
45 Rudder [illegible]
46 Fuselage [illegible] frame members
47 [illegible]
48 Radio [illegible]
49 [illegible]
50 Longeron [illegible]
51 Fuselage [illegible]
52 [illegible]
53 [illegible]
54 [illegible]
55 [illegible]
56 Radio seat support frame
57 Rudder [illegible]
58 Control [illegible]
59 Radio [illegible]
60 [illegible]
61 Windscreen
62 Windshield frame
63 Radio [illegible]
64 Windshield
65 Jettisonable forward [illegible]
66 Fuselage upper wing reinforcement [illegible]
67 Hydraulic [illegible]
68 Upper [illegible] spar
69 [illegible]
70 Wing [illegible]
71 [illegible]
72 [illegible]
73 Aileron [illegible]
74 Interplane [illegible]
75 Wing [illegible]
76 [illegible]
77 [illegible]
78 Wing [illegible]
79 [illegible]
80 [illegible]
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95 [illegible]
96 [illegible]
97 Cartridge [illegible]
98 Fuselage main fuel tank
99 [illegible]
100 [illegible]
101 [illegible]
102 [illegible]
103 [illegible]
104 [illegible]
105 [illegible]
106 [illegible]
107 Supplementary [illegible]
108 Engine [illegible]
109 [illegible]
110 [illegible]
111 [illegible]
112 [illegible]
113 [illegible]
114 Engine cowling ring
115 Exhaust [illegible]
116 Flowing [illegible]
117 [illegible]
118 [illegible]
119 [illegible]
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58 [illegible]

Right: CR.42s of the 828 Squadriglia of the 6° Gruppo Regia Aeronautica, photographed over the Aegean in '44 while operating from Kerpathos.

Polikarpov I-153 (mid 1938)

With the dawn of the forties the fighter biplane possessed barely more relevance to aerial warfare than did cavalry to a land battle. Nevertheless, the Soviet Union, which paradoxically, had been in the vanguard of the development of cantilever monoplane fighters with retractable undercarriages, had persisted, like Italy, in its belief in the biplane long after this configuration for fighters had been discarded by the other major air powers.

Some difficulties experienced by I-16 pilots in combatting the supremely agile Fiat CR.32 biplane had led to a Soviet decision to continue pursuit of fighter biplane development. Nikolai N. Polikarpov being assigned the task of evolving as expeditiously as possible a new and more potent warplane of this type. Responsibility for the project was given by Polikarpov to one of his principal design team leaders, Alexsei Ya Shcherbakov, who, in order to accelerate development based the new fighter on the existing I-152 (I-15bis), the basic structure of which, albeit refined in detail, and extensively re-stressed, was retained. The drag-evoking centre section cabane of the I-152 was rejected the upper wing roots being neatly "galled" into the fuselage,

Above: Airborne [illegible]

and a complex but ingenious main undercarriage retraction system was adopted.

The project received official approval on 11 October 1937 as the I-153 (alternatively I-15 ter), prototypes completing State Acceptance Tests in the autumn of 1938. Production was immediately begun at Factories Nos 1 and 156 in the Moscow area, initial deliveries commencing during the late spring of 1939. The first I-153s were hurriedly sent to participate in the so-called "Nomonhan" fighting between Russo-Mongolian and Japanese forces in the summer of 1939, the results achieved being sufficient to disillusion the most ardent biplane protagonists. It was manifestly obvious that the reasoning behind the I-153 had been fundamentally unsound.

Two factories were already engaged in large-scale I-153 production, however, so the programme, during the 18-month production life of the I-153 deliveries averaged 48 weekly, had to be continued until the last weeks of 1940 when 3,437 had been built. The I-153 was thus numerically the second most important fighter in the Soviet inventory when the Wehrmacht attacked, June 1941.

SPECIFICATION: I-153

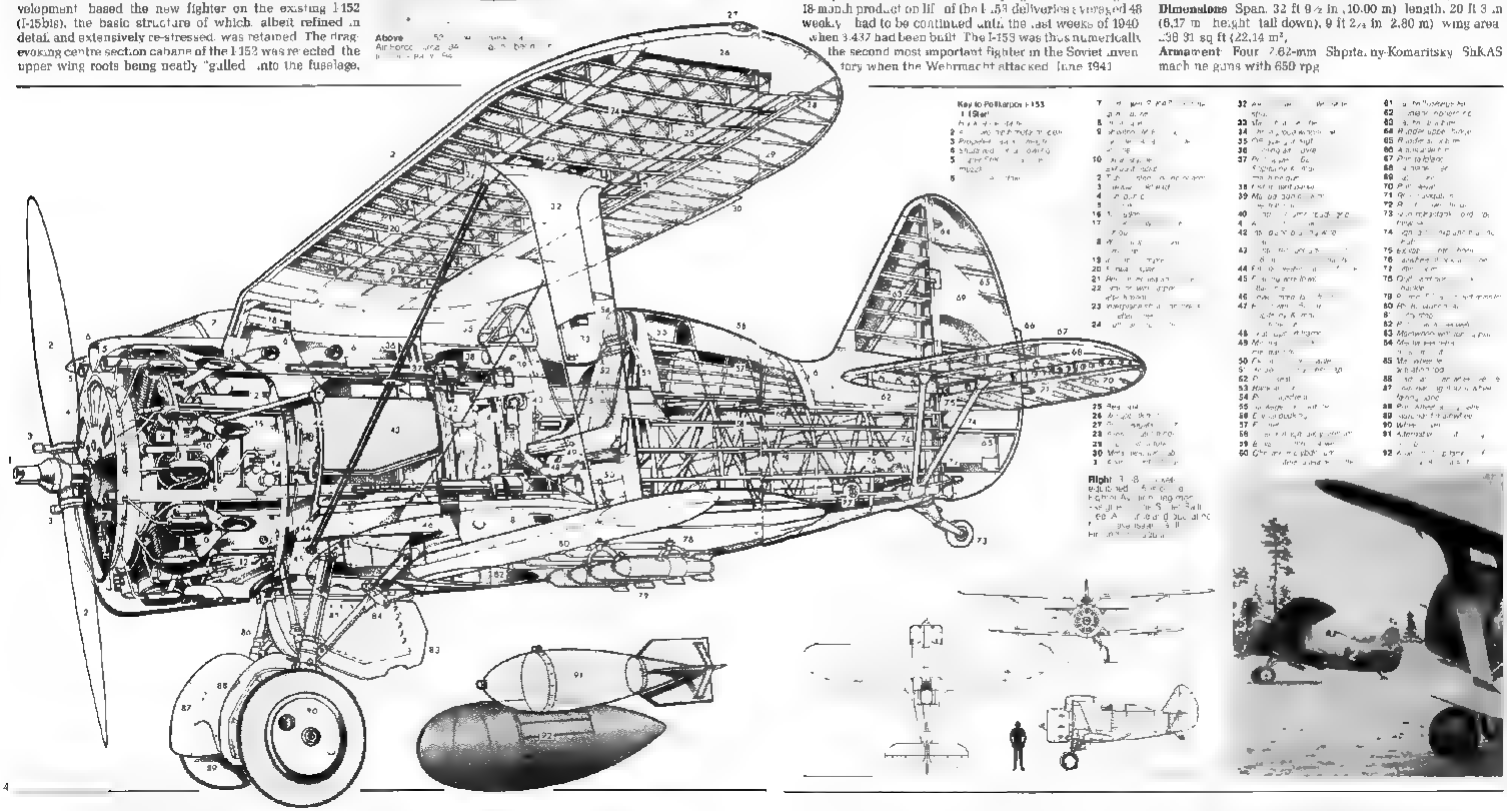
Power Plant: One Shvetsov M-62 nine-cylinder radial air-cooled engine rated at 1,000 hp at 2,200 rpm for take-off and 850 hp at 5,020 ft (1,530 m). Two-bladed two-pitch metal AV-1D or -2 propeller. Internal fuel capacity, 66 Imp gal (310 l) with provision also for two 17 8 Imp gal (80 l) auxiliary fuel tanks.

Performance: Max speed 222 mph (366 km/h) at sea level, 280 mph (452 km/h) at 15,000 ft (4,600 m), normal cruise, 184 mph (297 km/h) at 6,560 ft (2,000 m); range (internal fuel), 292 mls (470 km) at 184 mph (297 km/h), with auxiliary tanks), 497 mls (800 km) at 168 mph (270 km/h); time to 9,280 ft (1,000 m), 0.85 min, to 9,840 ft (3,000 m), 1.0 min, to 16,400 ft (5,000 m), 5.3 min.

Weights: Empty equipped, 3,201 lb (1,452 kg); normal loaded, 4,221 lb (1,860 kg), max 4,652 lb (2,110 kg).

Dimensions: Span, 32 ft 9½ in (10.00 m); length, 20 ft 3 in (6.17 m); height (tail down), 9 ft 2½ in (2.80 m); wing area, 238.91 sq ft (22.14 m²).

Armament: Four 7.62-mm Shpitalny-Komaritsky ShKAS machine guns with 650 rpg.



Curtiss P-40 (October 1938)

In developing the P-40, Donovan Berlin and his team were capitalising on investment in an existing design rather than attempting an advance in the state of the fighter art; an unsaprring evolutive growth of an already proven airframe to produce a comparatively modest performance increment. In short, the P-40 was a straightforward extrapolation of its predecessor the P-36 alias Hawk 75A (see pages 82-83) and, as such, was to prove itself an indifferent and controversial fighter, lauded for its delightful handling characteristics and vilified for its lack of agility, praised for its sturdiness and abused for its inability to compete with its principal adversaries on anything like equal terms.

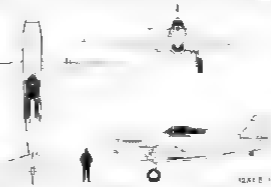
The shortcomings of the P-40 reflected unfavourably on the outmoded tactical concepts that gave it birth rather than the competence of the Curtiss design team. From the mid thirties, the ascendancy of bomber interceptor over pursuit doctrine had inhibited US fighter development. The US Army Air Corps saw the primary missions of the fighter as coastal defence and close air support, emphasis thus being placed on sturdiness and low altitude capability, the P-40's characteristics being a consequence of this concept.

The prototype ordered in July 1937 as a rework of the 10th production P-36 with an Allison V-1710 liquid-cooled engine, flew as the XP-40 on 14 October 1938, being dubbed Hawk 81A by its manufacturer. An order for 524 was placed on 27 April 1939 and the first production P-40 flew on 4 April 1940. The P-40 was extraordinarily robust and possessed sight and very effective aerons, thanks largely to which its handling characteristics were delightful, but it was lamentably lacking in practical capability by European standards. It possessed no protective armour or self-sealing tanks and its armament was restricted to a pair of rifles.

With delivery of the 200th aircraft as the first P-40B self-sealing fuel tanks and some armour were provided and armament was augmented by a pair of 0·50-in (12·7 mm) wing guns, the wing armament being doubled for the final 324 of the contract delivered as P-40Cs. Weight escalation had a deleterious effect on performance of these more battleworthy P-40s, with the result that their operational career was auspicious. Despite their manifest shortcomings, however, the RAF took on charge a total of 1,180 similar aircraft (including 230 from ex French contracts, which it designated as Tomahawks IIs, IIAs and IIBs (Hawks 81A-1s and -2s).

Availability of an uprated version of the V-1710 engine with an external spur reduction gear prompted redesign of the basic Hawk 81A as the Hawk 87A. The new

continued on page 198



SPECIFICATION, P-40C

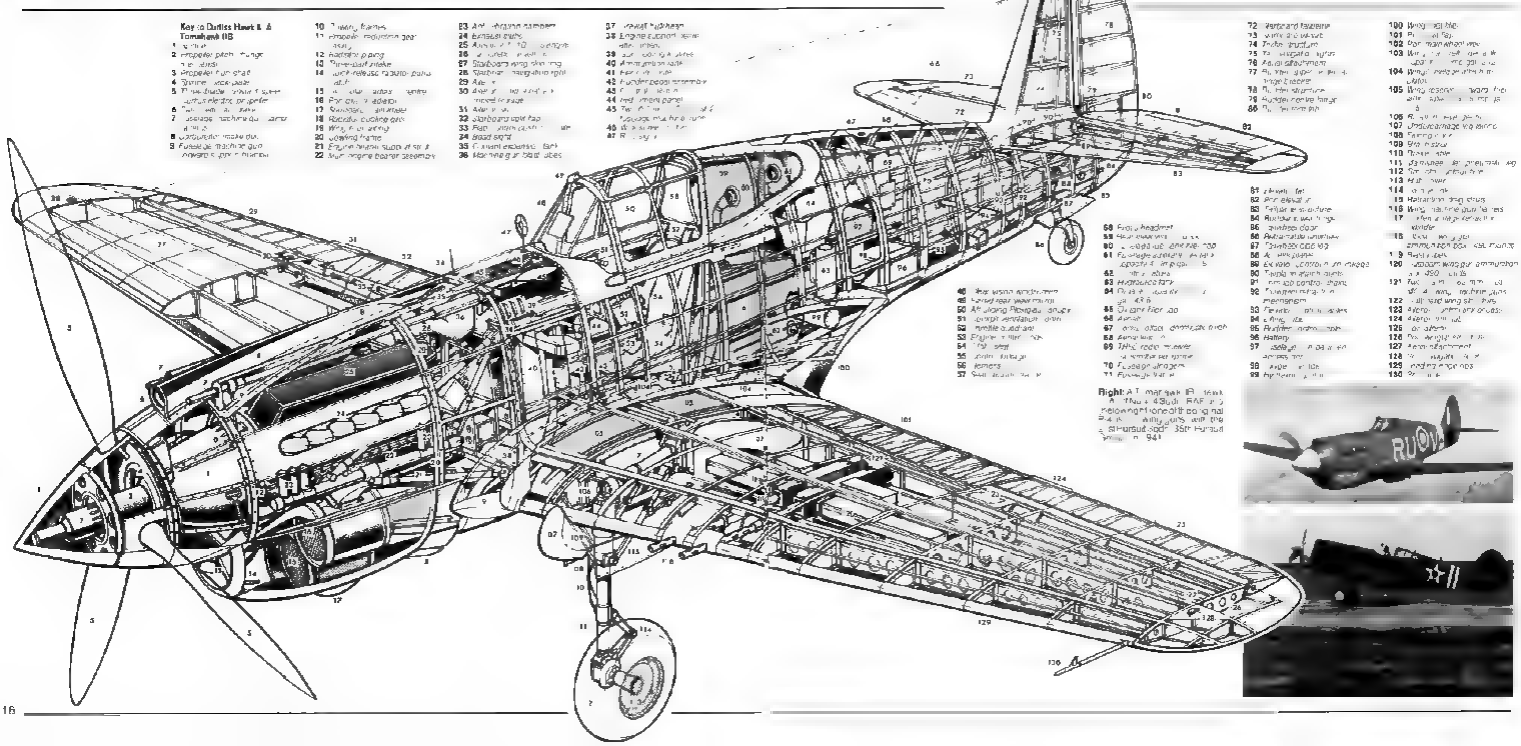
Power Plant: One Allison V-1710-33 12-cylinder vee liquid-cooled engine rated at 1,090 hp at 3,000 rpm for take-off and 1,040 hp at 15,000 ft (4,570 m). Three-bladed Curtiss constant-speed metal propeller. Internal fuel capacity, 192·6 Imp gal (603 l), including 33·7 Imp gal (153 l) reserve tank.

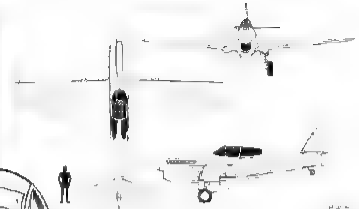
Performance: Max speed (at 7,327 lb 3,323 kg), 345 mph (555 km h) at 15,000 ft (4,572 m); max continuous cruise, 270 mph (434 km h); initial climb, 2,690 ft/min (13·66 m/sec); service ceiling, 29,500 ft (8,990 m); range (max internal fuel), 800 mls (1,287 km).

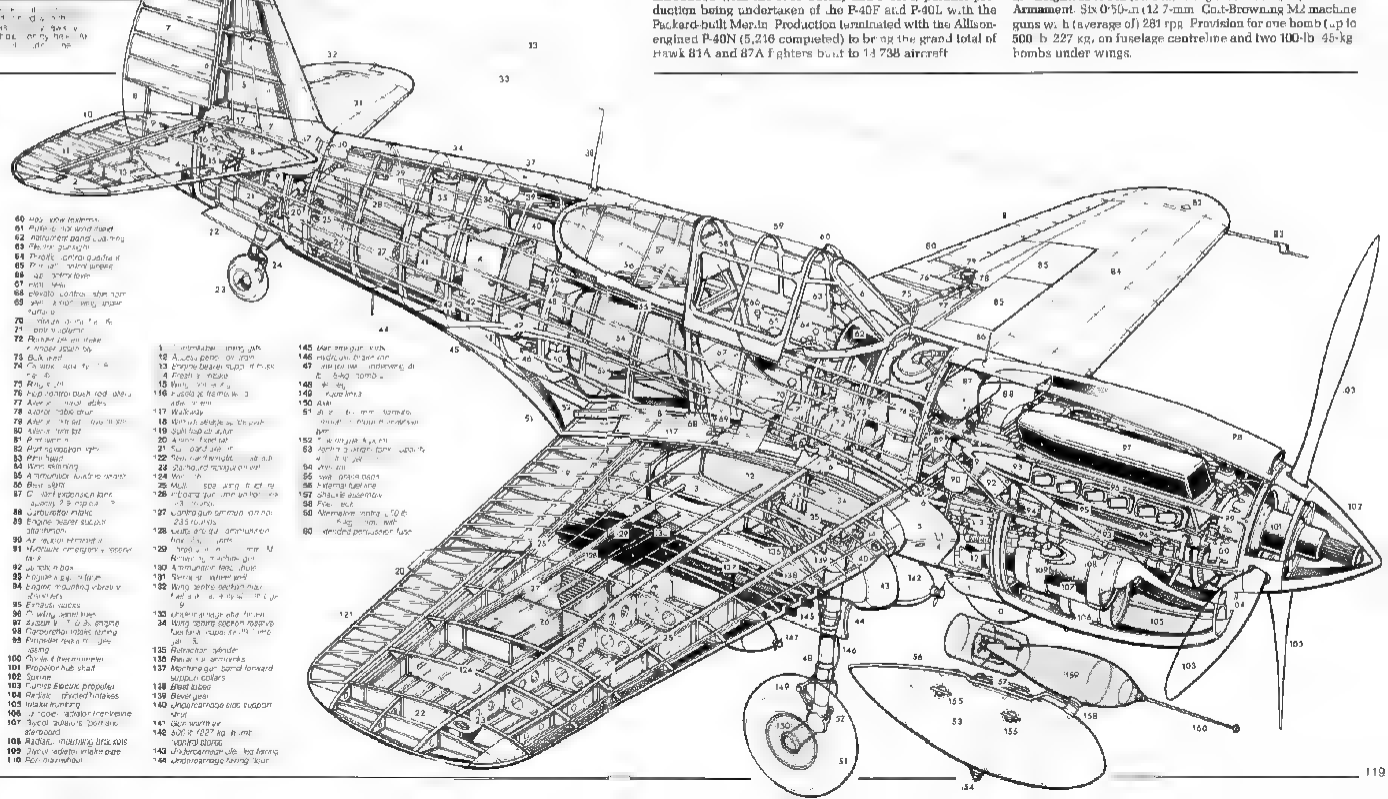
Weights: Empty equipped, 5,812 lb (2,636 kg); normal loaded, 7,349 lb (3,334 kg); max, 8,058 lb (3,655 kg).

Dimensions: Span, 37 ft 3 in (11·37 m); length, 31 ft 8·5 in (9·66 m); ht, 10 ft 7 in (3,22 m); wing area, 236 sq ft (21·92 m²).

Armament: Two 0·50-in (12·7 mm) Colt-Browning machine guns with 380 rpg and four 0·30-in (7·62 mm) Colt-Browning machine guns with 490 rpg.







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engine was shorter with a higher thrust line, necessitating redesign of the nose; the radiator was relocated, the fuselage cross section was reduced and the rear fuselage recontoured to improve pilot view aft and down. The new model flew as the Hawk 87A on 22 May 1941, and was already recipient of a British contract for 560 aircraft (Kittyhawk I). Parallel production was undertaken for the USAAF as the P-40D (first 22 aircraft) and P-40E, the latter having armament increased from four to six 'fifties', the name Warhawk being adopted.

The Warhawk was faster at altitude and more combat-worthy, but take-off performance, climb and manoeuvrability proved inferior. Orders were placed for 2,320 E-model fighters, 1 500 of these being purchased from Lend-Lease funds. Development of the Allison-engined version continued with the P-40K (a longer fuselage being introduced with the K 10 batch), and P-40M, parallel production being undertaken of the P-40F and P-40L with the Packard-built Merlin. Production terminated with the Allison-engined P-40N (5,216 completed) to bring the grand total of Hawk 81A and 87A fighters built to 13 738 aircraft.

SPECIFICATION: P-40E-1

Power Plant: One Allison V-1710-39 12-cylinder vee liquid-cooled engine rated at 1 150 hp at 3 000 rpm for take-off and as military power at 11 700 ft (3 570 m). Three-bladed Curtiss Electric constant-speed metal propeller. Internal fuel capacity 124 Imp gal (564 l) and provision for one 43 Imp gal (197 l) drop tank.

Performance: Max speed 335 mph (539 km/h) at 5,000 ft (1 525 m), 362 mph (582 km/h) at 15 000 ft (4 575 m), max continuous cruise 296 mph (476 km/h) at 5 000 ft (1 525 m), 312 mph (502 km/h) at 15 000 ft (4 575 m); time to 5 000 ft (1 525 m) 2.4 min, to 15 000 ft (4 575 m) 7.6 min; range (internal fuel at max continuous cruise) 525 mls (845 km).

Weights: Empty equipped 6 350 lb (2 880 kg), normal loaded 8 400 lb (3 814 kg), max 9 100 lb (4 131 kg).

Dimensions: Span 37 ft 4 in (11 38 m), length 31 ft 9 in (9 68 m), height 12 ft 4 in (3.76 m), wing area 236 sq ft (21.92 m²).

Armament: Six 0·50-in (12·7-mm) Colt-Browning M2 machine guns with (average of) 281 rpg. Provision for one bomb (up to 500 lb/227 kg) on fuselage centreline and two 100-lb (45-kg) bombs under wings.

Key to Curtiss P-40E Kittyhawk I

1 Rudder aerodynamic balance
2 Rudder upper hinge [illegible]
3 Rudder [illegible] bracket [illegible]
4 Rear navigation light (port and starboard)
5 Fin structure
6 Rudder [illegible]
7 Rudder structure
8 Rudder [illegible]
9 Rudder trim tab push-rod [illegible]
10 Elevator tab
11 Elevator structure
12 Elevator aerodynamic balance
13 Tailplane structure
14 Rudder lower hinge
15 Rudder [illegible]
16 [illegible]
17 [illegible]
18 Elevator control [illegible]
19 [illegible]
20 Tailwheel retraction mechanism
21 [illegible]
22 Tailwheel doors
23 Retractable tailwheel
24 Tailwheel leg
25 [illegible]
26 Tailwheel [illegible] attachment
27 [illegible]
28 Elevator [illegible] cables
29 Tailwheel upper attachment
30 Access panel
31 [illegible]
32 [illegible]
33 Radio aerial
34 [illegible]
35 Hydraulic reserve tank
36 [illegible]
37 Aerial lead-in
38 Radio aerial mast
39 Hand starter crank stowage
40 Radio [illegible] access door, port
41 Radio receiver/transmitter
42 [illegible] frame
43 Battery stowage
44 [illegible]
45 Hydraulic system vent line
46 [illegible]
47 [illegible]
48 Radio equipment mounting [illegible]
49 Hydraulic tank
50 Hydraulic pump
51 [illegible]
52 [illegible]
53 Wing centreline splice
54 Fuselage fuel tank [illegible]
55 Canopy frame
56 [illegible]
57 Rear vision panels
58 [illegible]
59 Rearward-sliding cockpit canopy
60 [illegible]
61 [illegible]
62 Instrument panel [illegible]
63 [illegible]
64 Throttle [illegible]
65 [illegible]
66 [illegible]
67 [illegible]
68 Elevator control [illegible]
69 [illegible]
70 [illegible]
71 [illegible]
72 Rudder pedals [illegible]
73 Bulkhead
74 [illegible]
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76 [illegible]
77 Aileron [illegible]
78 Aileron [illegible]
79 Aileron [illegible]
80 [illegible]
81 [illegible]
82 Port navigation light
83 [illegible]
84 [illegible]
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86 [illegible]
87 [illegible]
88 Carburettor intake
89 Engine bearer [illegible]
90 Air [illegible]
91 Hydraulic emergency reserve tank
92 [illegible]
93 [illegible]
94 Engine mounting vibration absorbers
95 Exhaust stacks
96 [illegible]
97 Allison [illegible] engine
98 [illegible]
99 Propeller [illegible]
100 [illegible]
101 Propeller hub shaft
102 Spinner
103 Curtiss Electric propeller
104 [illegible]
105 [illegible]
106 [illegible]
107 [illegible]
108 Radiator mounting brackets
109 [illegible]
110 [illegible]
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115 [illegible]
116 [illegible]
117 Walkway
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119 [illegible]
120 Aileron [illegible]
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122 [illegible]
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124 [illegible]
125 [illegible]
126 [illegible]
127 [illegible] 235 rounds
128 [illegible]
129 [illegible]
130 Ammunition feed chute
131 [illegible]
132 [illegible]
133 [illegible]
134 Wing [illegible]
135 Retraction cylinder
136 [illegible]
137 [illegible]
138 [illegible]
139 [illegible]
140 Undercarriage [illegible]
141 [illegible]
142 [illegible]
143 Undercarriage leg fairing
144 Undercarriage fairing [illegible]
145 [illegible]
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157 [illegible]
158 [illegible]
159 Alternative [illegible]
160 [illegible]

Dewoitine D 520 (October 1938)

It was France's misfortune that, when WW1 commenced, her aircraft industry had only just begun to recover the creativity in fighter design displayed in the early thirties. The M.S.406 (see pages 88-89) had proved pedestrian in both concept and capability, and the Bloch 152 (see pages 106-107), as the end product of an unduly protracted gestation, was to lack some qualities vital for success in fighter-versus-fighter combat. The D 520, on the other hand fully restored French fighter design to international standards: the tragedy was that quantity availability came too late seriously to affect the issue in French skies in the summer of 1942.

Designed by Emile Dewoitine in collaboration with Robert Castello and Jacques Henrat, the D 520 met a requirement formulated in June 1936. Of all-metal stressed-skin monocoque construction with a monospar wing, it placed emphasis on manufacturing economy by minimizing machined parts and sub-assemblies and stressing component interchangeability. Aerodynamically refined and structurally robust, the first of three D 520 prototypes flew on 2 October 1938, and an initial production order was placed on the following 14 March. The first production example was flown seven months later on 31 October 1939, but, regrettably, difficulties with the Hispano-Suiza 12Y-45 engine and various technical shortcomings, such as inadequate engine cooling and an unsatisfactory pneumatic machine gun control system, were to frustrate delivery schedules. In consequence only one Groupe de Chasse was to be mounted on the D 520 when the Wehrmacht launched its assault on 10 May 1940.

While incapable of competing with its principal opponent, the Bf 109E, in level speed and low-altitude climb, the D 520 enjoyed a marked edge in manoeuvrability and offered excellent diving characteristics. Its most serious shortcomings were a lack of damping in yaw, oversensitivity to turbulence and abrupt use of the throttle, and a tendency to ground loop. Further Groupes were hurriedly converted during summer 1940, and acquitted themselves honourably despite their pilots' unfamiliarity with the D 520. 403 of 437 completed were taken on charge by the Armée de l'Air at the time of the Armistice, and 478 more were built before and after German occupation of Vichy France.

SPECIFICATION D 520

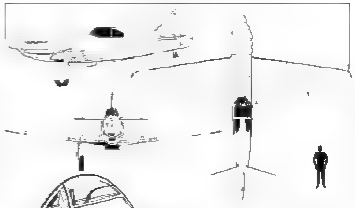
Power Plant: One Hispano-Suiza 12Y-45 12-cylinder vee liquid-cooled engine rated at 947 bhp at 2,520 rpm for take-off, 838 bhp at sea level and 907 bhp at 13,780 ft (4,200 m). Rateau 1808M or Chauvière three-bladed constant-speed propeller. Internal fuel capacity, 140 Imp gal (636 l).

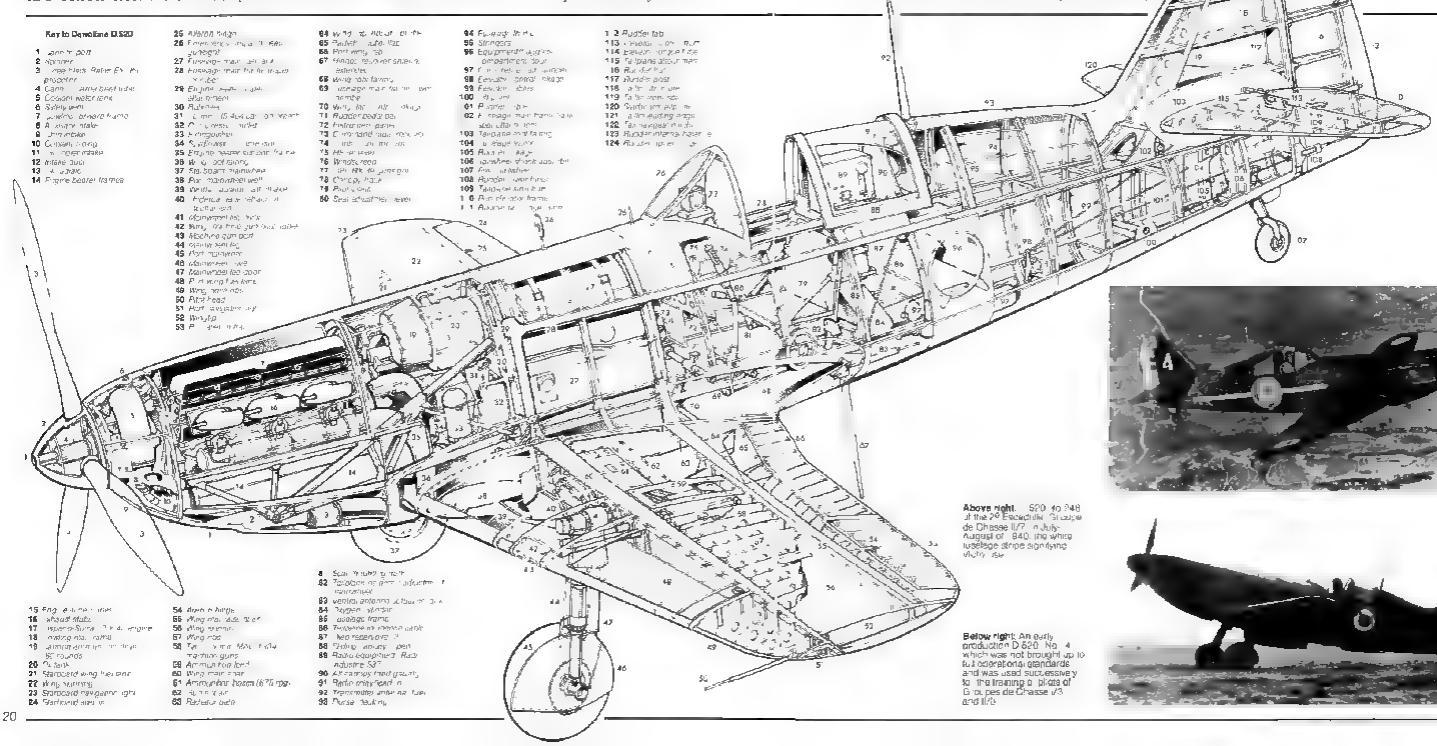
Performance: Max speed 284 mph (325 km/h) at sea level, 314 mph (505 km/h) at 13,125 ft (4,000 m), 332 mph (535 km/h) at 18,045 ft (5,500 m). Range (max internal fuel) 857 mls (1,540 km) at 230 mph (370 km/h) at 16,730 ft (5,100 m); time to 13,125 ft (4,000 m) 5.92 min; to 19,680 ft (6,000 m) 8.98 min; service ceiling, 33,620 ft (10,245 m).

Weights: Empty 4,468 lb (2,026 kg); normal loaded, wing tanks empty 5,902 lb (2,677 kg); max take-off 6,144 lb (2,787 kg).

Dimensions: Span 33 ft 5¼ in (10.20 m); length 28 ft 2¾ in (8.60 m); height (tail down) 8 ft 5½ in (2.57 m); wing area, 171.9 sq ft (15.97 m²).

Armament: One 20-mm Hispano-Suiza HS 404 cannon with 60 rounds and four 7.5-mm machine guns with 875 rpg.





Above right: D520 to 248 of the 2e Escadrille, 1st Groupe de Chasse (I/2), in July-August of 1940, the white fuselage stripe signifying Vichy flak.

Below right: An early production D 520, No. 4, which was not brought up to full operational standards and was used successively for the training of pilots of Groupes de Chasse I/3 and II/3.

Lockheed P-38 Lightning (January 1939)

USA

Uniquely can rarely be ascribed with justification to a fighter but the combination of features embodied by the P-38 assuredly rendered it unique. Born of a reawakening of interest in the twin-engined single seat fighter configuration conceived in WWI and resurrected in the mid 1930s virtually simultaneously in Britain, Germany and France—the P-38 was designed not only such warplane powered by piston engines to achieve large-scale production and extensive service in WWII.

The P-38 was the first fighter with a nosewheel undercarriage and the first single-seat fighter of twin boom arrangement to achieve service. It was the first squadron fighter with turbo-superchargers. It was to become the first aircraft known to have encountered the compressibility phenomenon and the first fighter equipped (from the late series P-38J) with power-boosted controls.

Designed by H. L. Hibbard to meet a far-sighted proposal for an innovatory twin-engined interceptor circulated early in 1936, the prototype Lightning, the XP-38, weighing more than a bombed up Blenheim then Britain's standard medium bomber and possessing a wing loading almost twice that of contemporary fighters, flew on 27 January 1939. Deliveries of the first "battle-worthy" mode, (P-38D) commencing in August 1941. Four years later in August 1945 when production ended, 9,923 P-38s had been delivered.

SPECIFICATION P-38J-25 Lightning

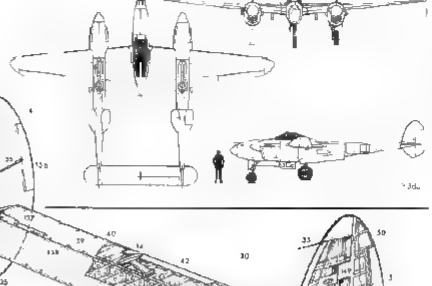
Power Plant: Two Allison V-1710-89/91 12-cylinder vee liquid-cooled engines each rated at 1,425 hp at 3,000 rpm for take-off and 1,425 hp at 26,500 ft (8,075 m). Three-bladed Curtiss Electric constant-speed metal propellers. Internal fuel capacity 341 Imp gal (1,552 l) and provision for two drop tanks of from 62.5 Imp gal (284 l) to 250 Imp gal (1,136 l) capacity.

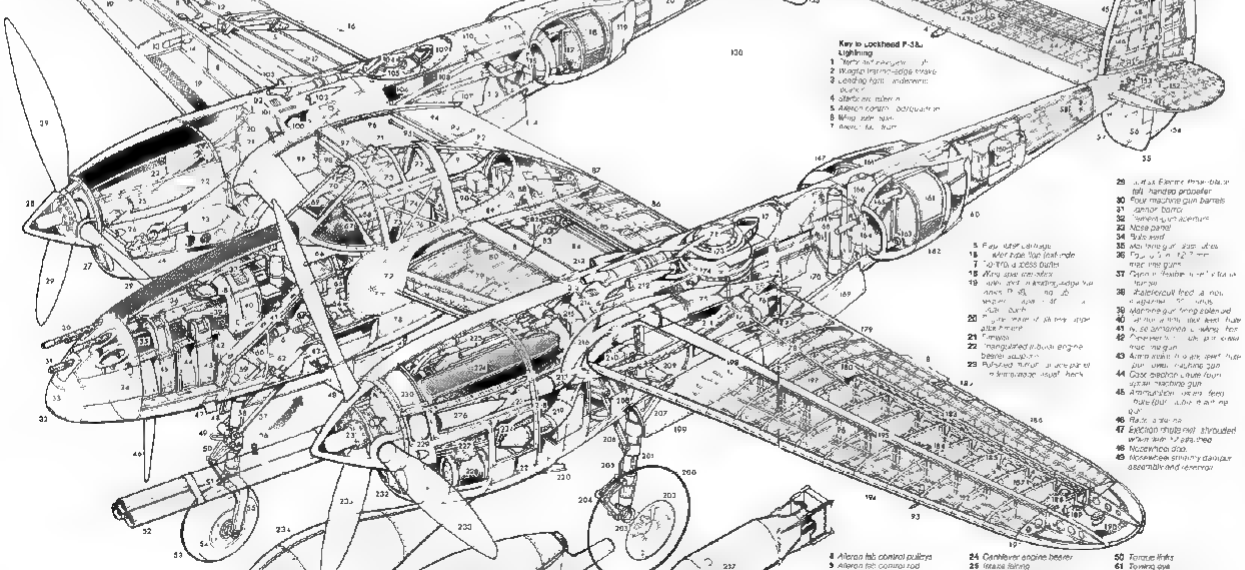
Performance: Max speed 360 mph (579 km h) at 5,000 ft (1,525 m), 390 mph (628 km h) at 15,000 ft (4,575 m), 414 mph (666 km h) at 25,000 ft (7,625 m); range (internal fuel) 840 mls (1,352 km), max external fuel 1,880 mls (3,025 km); max climb 3,670 ft/min (18.6 m/sec) at 5,000 ft (1,525 m); time to 30,000 ft (9,150 m), 12.0 min.

Weights: Empty equipped, 14,100 lb (6,401 kg); normal loaded 17,500 lb (7,945 kg), max, 21,600 lb (9,800 kg).

Dimensions: Span, 52 ft 0 in (15.85 m); length, 37 ft 10 in (11.53 m); height, 12 ft 10 in (3.91 m); wing area, 328 sq ft (30.50 m²).

Armament: One 20-mm AN-M2 "C" cannon with 150 rounds and four 0·50-in (12.7-mm) machine guns with 500 rpg.





Nakajima Ki.43 Hayabusa (January 1939)

Effectively an extrapolation of the preceding Ki.27 (see pages 102-103) in adhering to the same design precepts, so closely did the Ki.43 follow the established formula that its only concessions to contemporary fashion were a modest increase in power and an hydraulically-retractable undercarriage. The Army specification formulated at the end of 1937 and to the requirements of which the Ki.43 was developed had been singular in its lack of imagination and total disregard for international fighter trends. The Ki.43 was, in consequence, to be overshadowed by obsolescence from the moment of its birth.

Designed by the team responsible for the Ki.27 and with similar structural weight consciousness, the Ki.43 flew early in January 1939 but two years were to elapse owing to a combination of development difficulties and tardiness on the part of the procurement authority, before, on 9 January 1941 it was finally to be ordered into production as the Army Type 1 Fighter. Acceptances of the initial model, the Ki.43-I-ko commenced in the following June, but only two Sentai had converted when the Pacific War began.

Insofar as agility was concerned, the Ki.43 knew no peer. It could be looped and immelmanned at airspeeds of 186 mph (270 km/h) and lower acceleration from low airspeeds was exceptional, stall recovery was impeccable, and its so-called "butterfly" combat flaps endowed it with an astonishing rate of turn. On the other hand, it lacked firepower, armour and fuel tank protection, and its structure, while not fragile could not absorb much punishment. Furthermore it could be out-dived and out-zoomed by most Allied fighters.

The fundamental components of the Ki.43's structure did not permit power or armament increases commensurate with the demands of the air war and thus although production was to continue until the end of the conflict, despite obsolescence, only modest improvements were made. The Ki.43-I-ko soon gave place to the Ki.43-I-hei which supplanted the 7.7 mm guns with 12.7 mm weapons, and the Ki.43-II-ko, introduced in November 1942, received the marginally more powerful Ha-115 engine with two-speed supercharger and a three-blade constant-speed propeller. As the war progressed, the Ki.43 was invariably outclassed, but committed on every front, it soldered on as numerically the most important Army fighter with a total of 5,919 built.

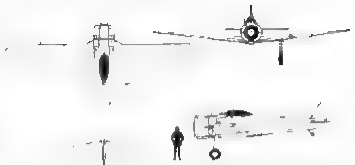
SPECIFICATION, Ki.43-I-hei

Power Plant: One Nakajima Ha-25 14-cylinder radial air-cooled engine rated at 980 hp at 2,700 rpm for take-off and 970 hp at 11,155 ft (3,400 m). Two-bladed two-pitch metal propeller. Internal fuel capacity, 125 Imp gal (564 l) plus two internal (wing) 33 Imp gal (150 l) overload tanks and provision for two 44 Imp gal (200 l) drop tanks.

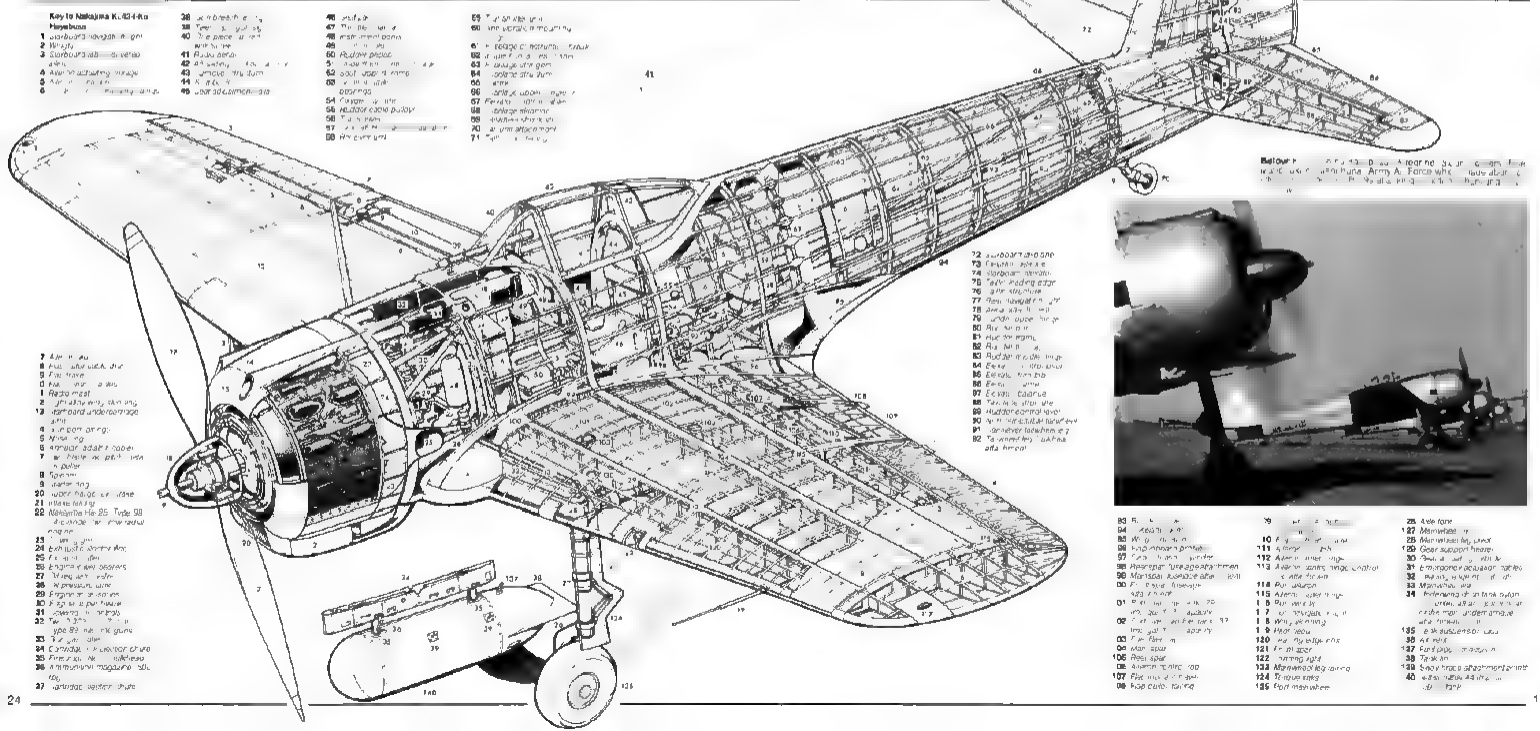
Performance: Max speed, 274 mph (441 km/h) at 3,280 ft (1,000 m), 285 mph (460 km/h) at 6,560 ft (2,000 m), 298 mph (479 km/h) at 9,840 ft (3,000 m), 306 mph (492 km/h) at 16,405 ft (5,000 m); normal cruise, 236 mph (380 km/h) at 6,200 ft (2,500 m); range (internal fuel, including overload tanks), 746 mls (1,200 km) at 217 mph (350 km/h), 805 mls (1,300 km) at 202 mph (325 km/h); time to 16,405 ft (5,000 m), 5.5 min; service ceiling, 38,550 ft (11,750 m).

Weights: Empty equipped, 3,505 lb (1,589 kg); normal loaded, 4,516 lb (2,048 kg); max, 5,694 lb (2,583 kg).

Dimensions: Span, 37 ft 6 in (11.44 m); length, 28 ft 1¼ in (8.56 m); height, 10 ft 8¾ in (3.27 m); wing area, 236.8 sq ft (22.00 m²).



Armament: Two 12.7 mm Ho-103 (Type 1) machine guns with 250 rpg and provision for two 33-lb (15-kg) bombs under wing.



Below: [illegible] Nakajima Ki.43-I-ko Hayabusa Army Air Force [illegible]

Mitsubishi A6M Reisen (April 1939)

The philosophy of exercising the most rigid weight consciousness in order to achieve the characteristics demanded of a pure air superiority fighter employed with success by Jiro Horikoshi in the A5M (see pages 76-79) was again to be pursued in the development of a successor, the A6M Reisen (Zero Fighter). Within little more than two years of the operational deployment of the new fighter however it was to be realised that its concept was already atrophic: its structure, design features rendered it insufficiently amenable to the changes demanded by combat experience. The Reisen, which briefly enjoyed aerial mastery over the Pacific, thus rapidly declined in effectiveness.

Designed to a 12 Shi (1937) specification and first flown on 1 April 1939, the A6M was ordered into series production as the Navy Type 0 Carrier Fighter in July 1940, the same month in which pre-series A6Ms appeared operational over China, and when the Pacific War commenced 328 A6M2s were on Imperial Navy strength. At normal close-in high g dogfighting speeds, the A6M was superlatively manoeuvrable: the Allies credited it with almost mystical powers of manoeuvre, but in all other respects it was rapidly outclassed by the newer Allied fighters.

The failure of the succeeding generation of Navy fighters to achieve service rapidly dictated retention of the Reisen in production despite its obsolescence: successive versions embodying various palliatives intended to mitigate its inferiority in combat with strictly limited success, but production continued until the end of hostilities when a total of 11 800 had been delivered.

SPECIFICATION A6M2b Reisen Model 21

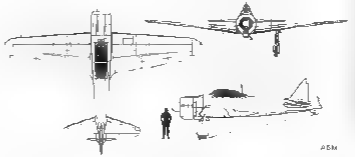
Power Plant One Nakajima NK1C Sakae 14-cylinder radial air-cooled engine rated at 940 hp at 2,600 rpm for take-off and 950 hp at 13,780 ft (4 200 m). Three-bladed Mitsubishi-Hamilton constant-speed metal propeller. Internal fuel capacity 114 Imp gal (518 l) with provision for a 72.5 Imp gal (330 l) drop tank.

Performance: Max speed, 332 mph (534 km/h) at 14,930 ft (4 550 m); 282 mph (454 km/h) at sea level; max continuous cruise, 207 mph (333 km/h); range (internal fuel), 1 160 mi (1 866 km) at 146 mph (235 km/h) at 1 500 ft (455 m), (with drop tank) 1 930 mls (3 105 km); initial climb, 3 300 ft/min (15,75 m/sec); time to 19,685 ft (6 000 m), 7 45 min; service ceiling, 33,790 ft (10 300 m).

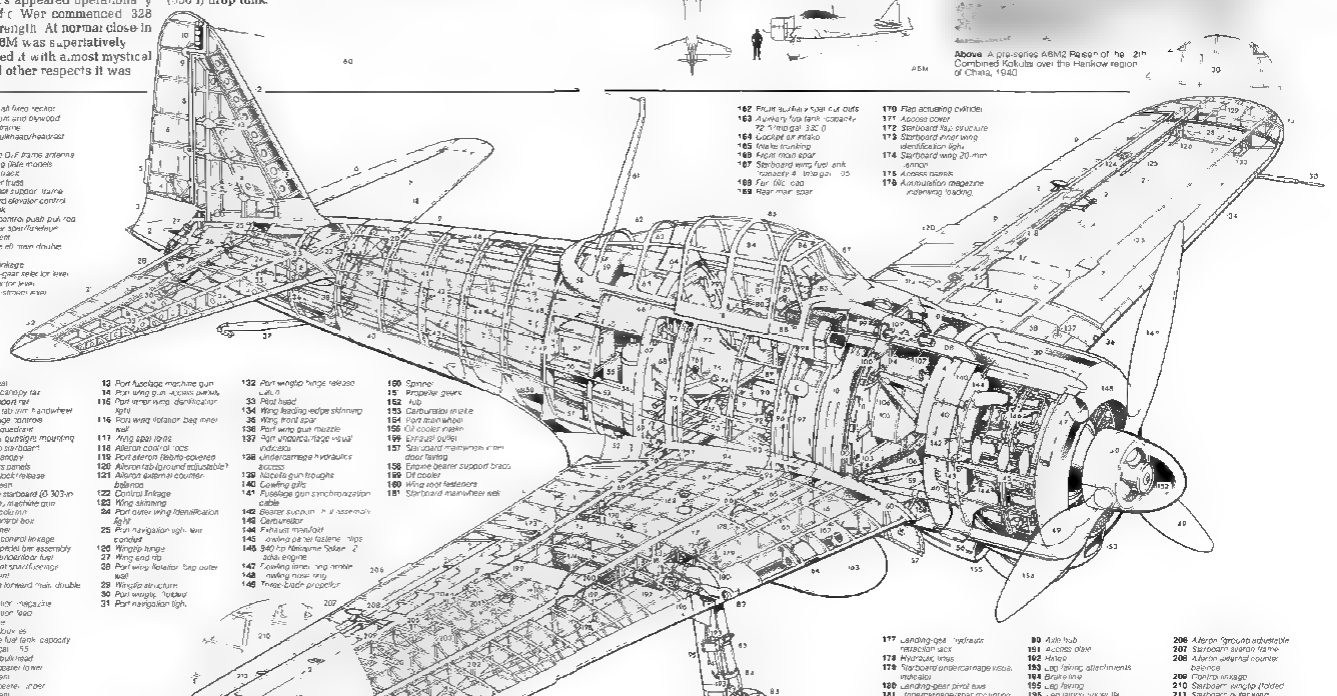
Weights: Empty equipped, 3 704 lb (1 680 kg); normal loaded, 5 313 lb (2 410 kg); max, 6,164 lb (2 796 kg).

Dimensions: Span, 39 ft 4½ in (12.00 m); length, 29 ft 8¾ in (9 06 m); height 10 ft 0¼ in (3.05 m); wing area 241 54 sq ft (22.44 m²).

Armament: Two 20 mm Navy Type 99 Mk 1 Oerlikon cannon with 60 rpg and two 7 7-mm Type 97 (Vickers) machine guns with 500 rpg.



Above A pre-series A6M2 Reisen of the 21st Combined Kokutai over the Hankow region of China, 1940



Key to Mitsubishi A6M2

1 Tail navigation light
2 Tail cone
3 Tailfin, fixed section
4 Rudder leading edge
5 Rudder tab (ground adjustable)
6 Fabric-covered rudder
7 Rudder hinge
8 Rudder post
9 Rudder upper hinge
10 Rudder control horn, welded to torque tube
11 Aerial attachment
12 Tailfin leading-edge
13 Tailfin spar
14 Tailfin structure
15 Tailfin nose ribs
16 Non-metallic
17 Port tailplane
18 Fabric-covered
19 Fuselage dorsal skinning
20 Control turnbuckles
21 Arrester hook release/retract steel spring
22 Fuselage frame/stringer centre-piece
23 Tailplane attachments
24 Elevator cables
25 Elevator control torque tube
26 Rudder control horns
27 Tailplane compressed structure stock spar
28 Elevator trim tab
29 Tailplane leg fairing
30 Cantilever tailplane
31 Elevator frame, fabric-covered
32 Elevator outer hinge
33 Tailplane structure
34 Forward spar
35 Elevator trim tab control rod (hinge-driven)
36 Fuselage flotation bag rear wall
37 Arrester hook (extended)
38 Arrester hook (rest) mounting
39 Elevator trim tab cable guide
40 Fuselage skinning
41 Fuselage frame sections
42 Arrester hook spring (retracting cable duralumin tube)
43 Rudder cables
44 Elevator cables
45 Trim gear cable runs
46 Arrester hook pulley guide
47 Fuselage stringers
48 Fuselage flotation bag port wall
49 Fuselage construction joint
50 Wing root fillet formers
51 Compressed air/nitrogen gun charging
52 Pressure/air
53 Ku type radio mast
54 Oxygen cylinder (starboard LH), fire extinguisher cylinder (port)
55 Batteries
56 Radio receiver, spare
57 Radio transmitter
58 Canopy/fuselage fairing
59 Aerial mast support/lead-in
60 Aerial
61 Aerial mast (forward raised)
62 Canopy aft fixed section
63 Aluminium and plywood canopy frame
64 Crash bulkhead/headrest support
65 Ku type D-F frame, antenna in rolling blade models
66 Canopy track
67 Turnover truss
68 Pilot's seat support frame
69 Starboard elevator control bell-crank
70 Aileron control push pull rod
71 Wing rear spar/fuselage attachment
72 Fuselage aft main double frame
73 Aileron linkage
74 Landing gear rear for level
75 Fairing for level
76 Tail adjustment level
77 Pilot's seat
78 Cockpit canopy rail
79 Seat support rail
80 Elevator tab trim handwheel
81 Fuel gauge sections
82 Throttle quadrant
83 Rotation guidance mounting cables on starboard
84 Sliding canopy
85 Fireplugs panels
86 Canopy lock release
87 Windscreen
88 Fuselage starboard (0 303-in 7 7-mm) machine gun
89 Control cable run
90 Radio control box
91 Radio tubes
92 Elevator control linkage
93 Rudder/pedal trim assembly
94 Control/elevator fuel
95 Wing inner spar/fuselage attachment
96 Fuselage forward main double frame
97 Ammunition magazine
98 Ammunition feed
99 Rear tube
100 Cockpit floor
101 Fuselage fuel tank capacity 34 Imp gal 13
102 Firewall bulkhead
103 Engine cooler lower attachment
104 Engine lower attachment
105 Oil tank capacity 12 Imp gal 54
106 Engine support cradle
107 Cowling gun actuation control
108 Machine gun muzzle mounts
109 Barrel fairing
110 Oil filler cap
111 Fuselage fuel tank filler cap
112 Port fan profile
113 Port fuselage machine gun
114 Port wing gun access panels
115 Port wing/wing distribution light
116 Port wing rotator bag inner wall
117 Wing spar joints
118 Aileron control rods
119 Port aileron fabric-covered
120 Aileron tab (ground adjustable)
121 Aileron external counter-balance
122 Control linkage
123 Wing skinning
124 Port outer wing flotation bag
125 Port navigation light, wing contact
126 Wing/tip hinge
127 Wing end rib
128 Port wing flotation bag outer wall
129 Wing/tip structure
130 Port wing/tip hinge
131 Port navigation light
132 Port wing/tip hinge release cable
133 Pitot head
134 Wing leading-edge skinning
135 Wing front spar
136 Port wing gun muzzle
137 Port undercarriage visual indicator
138 Undercarriage hydraulics access
139 Nozzle gun troughs
140 Cowling gills
141 Fuselage gun synchronization cable
142 Blister support frame assembly
143 Carburettor
144 Exhaust manifold
145 Cowling panel fastener clips
146 940 hp Nakajima Sakae 21 radial engine
147 Cowling trailing edge
148 Cowling nose ring
149 Three-blade propeller
150 Spinner
151 Propeller gears
152 Hub
153 Carburettor inlets
154 Port aileron
155 Oil cooler main
156 Exhaust outlet
157 Starboard mainwheel main door fairing
158 Engine bearer support brace
159 Oil cooler
160 Wing root fastenings
161 Starboard mainwheel well
162 Fuel surface fuel cut outs
163 Auxiliary fuel tank capacity 72 Imp gal 330 l
164 Cockpit air intake
165 Brake trunking
166 Right main spar
167 Starboard wing fuel tank capacity 4 Imp gal 18
168 Fair fillet cap
169 Rear main spar
170 Flap actuating cylinder
171 Access cover
172 Starboard flap structure
173 Starboard inner wing identification light
174 Starboard wing 20-mm cannon
175 Access panels
176 Ammunition magazine inboard wing loading
177 Landing-gear hydraulic retraction jack
178 Hydraulic lines
179 Starboard undercarriage visual indicator
180 Landing-gear pivot axis
181 Undercarriage spar mounting
182 Starboard wing gun muzzle
183 Starboard undercarriage leg
184 Oleo travel
185 Wheelbrake steel wheel fork
186 Wheel uplock latch
187 Starboard mainwheel
188 Wheel disc fairing bolt and swivel fastener
189 Mainwheel door fairing
190 Axle hub
191 Access plate
192 Hinge
193 Leg fairing attachments (inboard)
194 Brake line
195 Leg fairing
196 Leg fairing hydraulic lines
197 Wing gun barrel support cable
198 Wing nose ribs
199 Wing door joints
200 Carburettor exhaust
201 Wheel outlock attachment
202 Front spar upper section
203 Inner spar ribs
204 Rear spar outer section
205 Aileron control rod ends
206 Aileron (groups adjustable)
207 Starboard aileron frame
208 Aileron external counter-balance
209 Fairing linkage
210 Starboard wing/tip (folded)
211 Starboard outer wing identification light
212 Aileron outer hinge
213 Starboard wing flotation bag outer wall
214 Wing end rib
215 Starboard wing/tip hinge release cable
216 Starboard navigation light

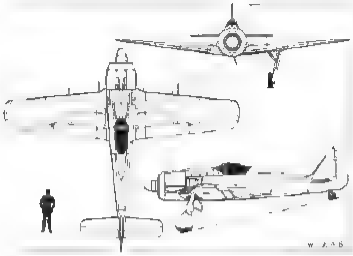
Focke-Wulf Fw 190 (June 1939)

Above: [illegible] Focke-Wulf Fw 190 [illegible] was designed by Dipl-Ing Kurt Tank [illegible]

If any fighter has, at the time of its operational debut, ever been able to lay claim to coming close to perfection, then that fighter was arguably the Fw 190 designed by Dipl-Ing Kurt Tank. It was not, of course, perfect – no fighter yet designed had been devoid of defects – but it certainly came closer to that state of grace than any contemporary.

Forsaking the liquid-cooled engine then considered de rigeur for fighters in Germany, in favour of an air-cooled radial, and first flown on 1 June 1939, the Fw 190 was a compact, well-proportioned warplane possessing superlative control harmony and being both a good dogfighter and a good gun platform. Its debut caused widespread RAF consternation in 1941. It could outperform the contemporary Spitfire V on every count apart from turning circle; its manoeuvre margins were limited by rather harsh stalling character. This balance was to be redressed, in part, by the Spitfire IX, but even this redoubtable fighter was left standing by the Fw 190's half-roll and dive.

The Fw 190 established a broad operational repertoire and 18,524 were to be delivered by the end of 1944, with a further 2,700 or so thereafter.



SPECIFICATION: Fw 190A-8

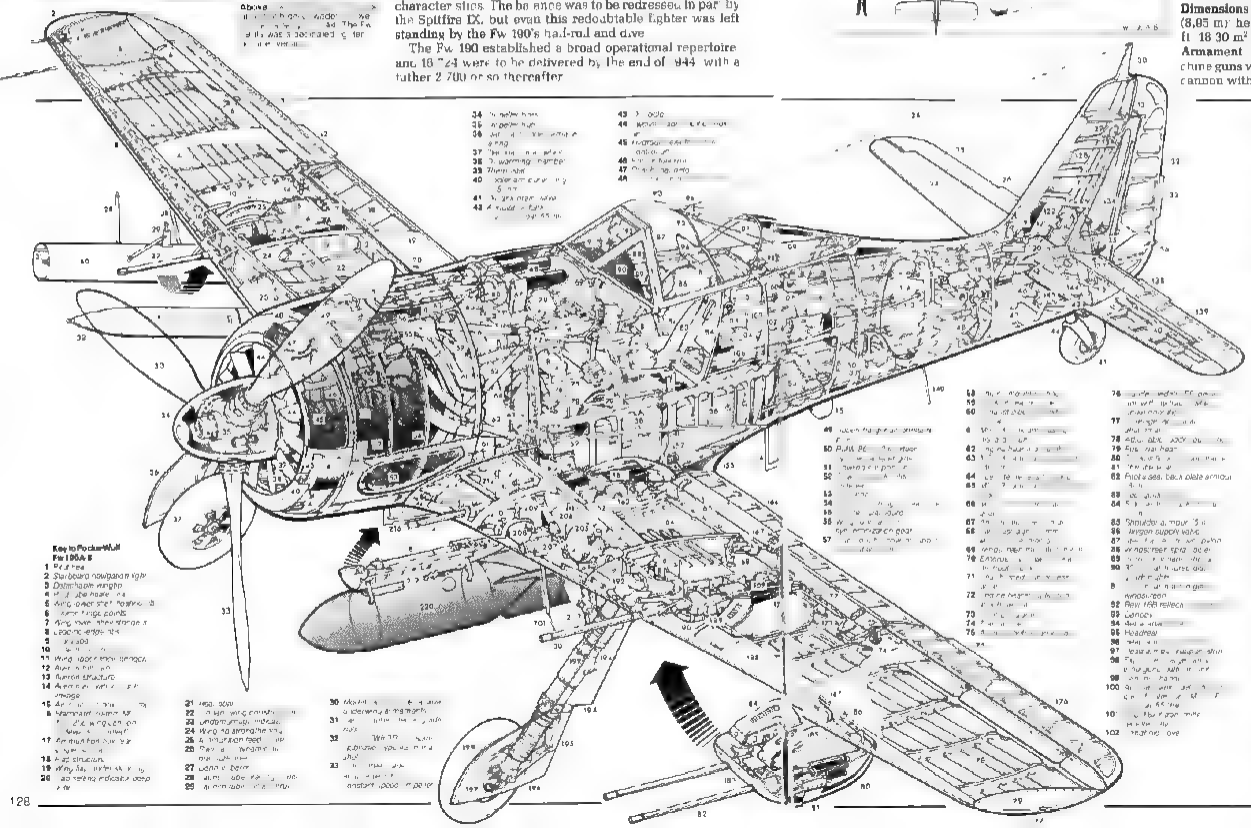
Power Plant: One BMW 801D 4-cylinder two-row radial air-cooled engine rated at 1,700 hp at 2,700 rpm for take-off and 1,440 hp at 18,700 ft (5,700 m). Three-bladed VDM constant-speed propeller. Internal fuel, 115.5 Imp gal (524 l).

Performance: Max speed, 355 mph (571 km/h) at sea level, 402 mph (647 km/h) at 18,045 ft (5,500 m) (with GM-1 nitrous oxide boost), 408 mph (656 km/h) at 20,670 ft (6,300 m); normal cruise, 298 mph (480 km/h) at 6,560 ft (2,000 m); max range (internal fuel), 644 mls (1,035 km) (with drop tank), 915 mls (1,470 km); initial climb, 3,450 ft/min (17,5 m/sec); service ceiling, 33,800 ft (10,300 m) (with GM-1), 37,400 ft (11,400 m).

Weights: Empty equipped, 7,652 lb (3,470 kg); normal loaded, 9,660 lb (4,380 kg); max, 10,724 lb (4,865 kg).

Dimensions: Span, 34 ft 5½ in (10,51 m); length, 29 ft 4¾ in (8,95 m); height, 12 ft 11½ in (3,95 m); wing area, 196,98 sq ft (18,30 m²).

Armament: Two 13-mm Rheinmetall-Borsig MG 131 machine guns with 475 rpg and four 20-mm Mauser MG 151 205 cannon with 250 rpg (inboard pair) and 140 rpg (outboard).



Key to Focke-Wulf Fw 190A-8

1 [illegible]
2 Starboard navigation light
3 Detachable engine [illegible]
4 Wing quick-release fairing
5 [illegible] fuselage points
6 [illegible]
7 Wing upper skin [illegible]
8 Upper wing [illegible]
9 [illegible]
10 [illegible]
11 Wing upper skin [illegible]
12 Aileron [illegible]
13 Aileron structure
14 Aileron [illegible]
15 [illegible]
16 Aluminium [illegible]
17 Aileron [illegible]
18 [illegible]
19 Wing [illegible]
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23 Undercarriage [illegible]
24 Wing to fuselage [illegible]
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102 [illegible]
103 Pitot tube
104 Auxiliary steering unit (PKS 12)
105 [illegible]
106 [illegible]
107 [illegible] bodies (starboard leading edge)
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160 Ammunition feed chute
161 Port wing-root MG 151 20B cannon
162 [illegible]
163 [illegible]
164 Upper and lower wing stringer
165 Rear spar
166 [illegible]
167 [illegible]
168 [illegible]
169 [illegible] wing garnish moulding in white
170 Aileron connection fitting
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Bristol Beaufighter (July 1939)

Many were to be the adaptations for fighter roles of aircraft conceived purely as bombers, the supreme example of such aeronautical versatility being provided by the Junkers Ju 88 (pages 104-105). This outstandingly polymorphous German aircraft was paralleled in the UK by another such example of improvised or, albeit a somewhat more dedicated fighter adaptation of an existing bomber. This, the Bristol Beaufighter was, like its German counterpart, to be numbered among WWII's most versatile warplanes.

To overcome the RAF's embarrassing lack of long-range heavy fighters, Leslie G. Frise and his team concerned late in 1938, a "minimum change fighter derivative of the Beaufort torpedo-bomber. Featuring more powerful engines and a redesigned forward fuselage, this flew as the Beaufighter on 17 July 1939. An inelegant aeroplane, brutally powerful in appearance, the Beaufighter was an aircraft towards which no pilot could be indifferent: it was either liked or heartily disliked.

Entering service in the nocturnal intercept role in September 1940 as the only RAF aircraft capable of carrying A. Mk IV radar without sacrificing either endurance or firepower, the Beaufighter displayed a measure of handling precocity. Extreme care had to be exercised to avoid an incipient swing during take-off; a side-to-side yawing during undercarriage retraction was not easily controllable, and prior to adoption of tailplane dihedral it suffered pronounced fore-and-aft instability, particularly noticeable in the climb and landing approach. It tended to pitch nose down when the cannon were fired and its controls were heavy. But the Beaufighter was an immensely strong, outstandingly robust aeroplane.

In the spring of 1941, the Beaufighter was introduced by RAF Coastal Command as a long range fighter. 915 Mk IIs being delivered before replacement of the Hercules III or XI engines by the Hercules VI resulted in the Beaufighter VI of which 1,682 were built. 60 of these as interim torpedo fighters with an 18-in (46 cm), or 22.5-in (57 cm) torpedo to enter service late 1942. With Hercules XVII engines, the definitive Beaufighter X torpedo fighter followed from 1943. 2,205 being built, together with 163 Beaufighter XICs lacking torpedo-carrying provision, production ending on 21 September 1945 with 5,562 Beaufighters built.

Above: A Beaufighter IF of No 604 Squadron in the autumn of 1940. The aerials of the A. Mk IV can be seen on wings and nose.

SPECIFICATION: Beaufighter IF

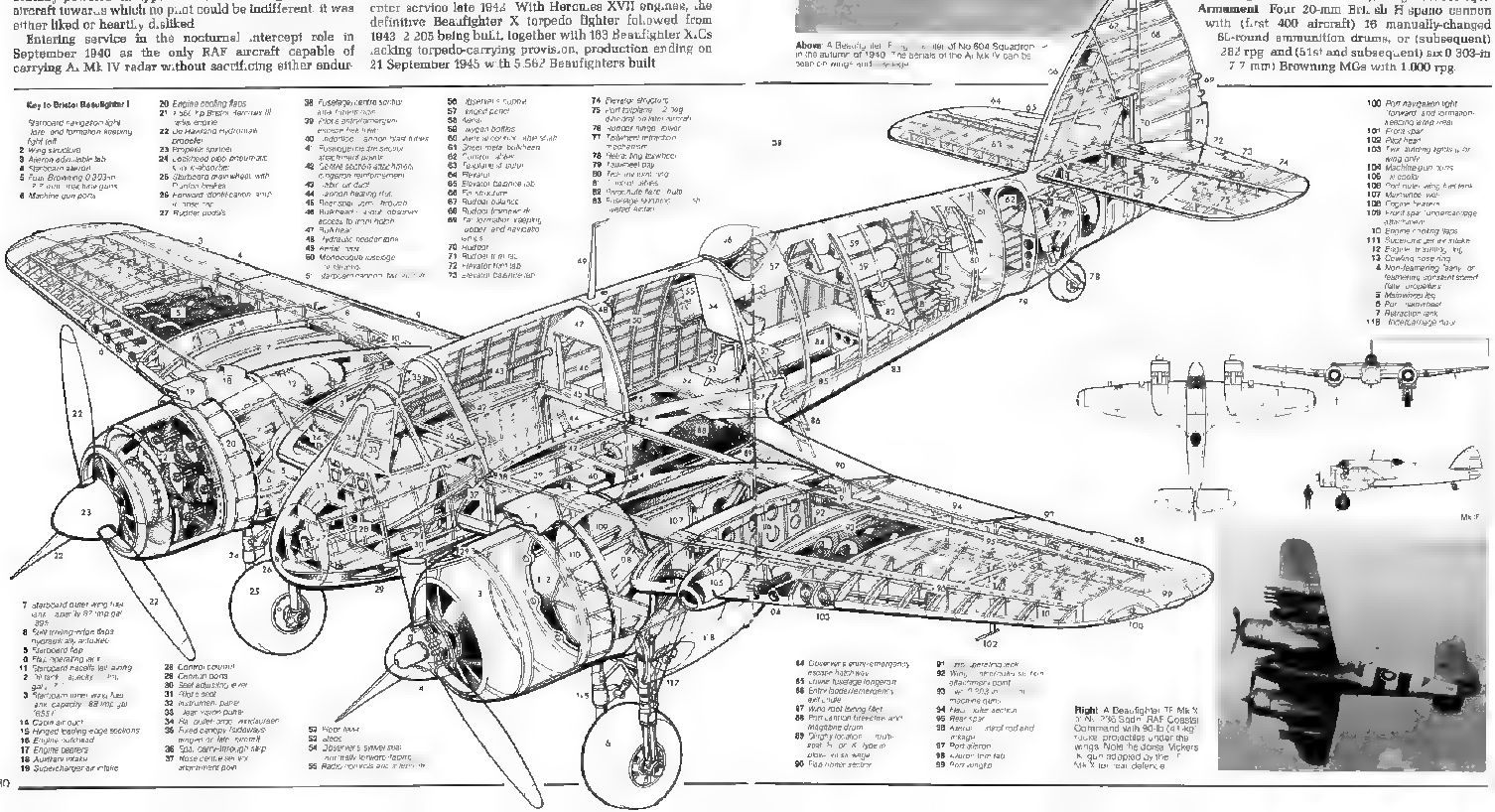
Power Plant: Two Bristol Hercules III or XI 14-cylinder two-row radial air-cooled engines each rated at 1,580 hp at 2,800 rpm for take-off and 1,410 hp at 10,750 ft (3,280 m). De Havilland or Rotol three-bladed constant-speed propellers. Normal internal fuel capacity: 550 Imp gal (2,500 l)

Performance: Max speed: 306 mph (492 km/h) at sea level, 323 mph (520 km/h) at 15,000 ft (4,570 m); max cruise: 272 mph (437 km/h) at 15,000 ft (4,570 m); normal range: 1,170 mls (1,883 km) at 182 mph (292 km/h) at 5,000 ft (1,525 m); initial climb: 1,850 ft/min (9.4 m/sec); time to 10,000 ft (3,050 m): 5.8 min; service ceiling: 26,500 ft (8,075 m).

Weights: Empty equipped: 14,069 lb (6,381 kg); max loaded: 21,100 lb (9,571 kg)

Dimensions: Span: 57 ft 10 in (17.63 m); length: 41 ft 4 in (12.60 m); height: 15 ft 10 in (4.82 m); wing area: 503 sq ft

Armament: Four 20-mm Brit. ski Hispano cannon with (first 400 aircraft) 16 manually-changed 60-round ammunition drums, or (subsequent) 282 rpg and (51st and subsequent) six 0.303-in (7.7 mm) Browning MGs with 1,000 rpg.



Right: A Beaufighter TF Mk X (NE 290 Sqdn RAF Coastal Command with 90-lb (41-kg) rocket projectiles under the wings. Note the dorsal Vickers K gun adopted by the TF Mk X for rear defence.

Hawker Typhoon (February 1940)

Aviation's history abounds with aircraft designed for one function only to find their mettle in another. Fighters have certainly not been immune to such transposition, several having been intended to operate in one specialised band of the fighter spectrum but establishing a true forte in a disparate arena. One such was the Typhoon—an abysmal failure in its intended role of high-altitude interceptor but a ground attack fighter *par excellence*.

Heaviest and most powerful single-seat single-engined warplane envisaged at the time of its inception and an object lesson in the danger of committing to production an undeveloped aeroplane, the Typhoon was ordered in quantity late in 1939, but did not fly as a prototype until 24 February 1940. From the outset, it suffered tribulations, which, although not stemming from fundamental airframe design were of such serious nature that on more than one occasion the entire programme came within an ace of cancellation. The problems of a notoriously unreliable engine were compounded by rear fuselage failures, and answers had still to be found when the Typhoon was committed to squadron service from September 1941.

An innately rugged aeroplane, with a thick, high lift wing of generous area, the Typhoon offered reasonable and precise aerobatic handling. Its stability was excellent and it was a good gun platform, but its controls were heavy, its low speed handling left much to be desired and it manifested a disappointing climb rate and an exceedingly poor performance above 20,000 ft (6 095 m). At lower altitudes it was very fast—it was the first RAF fighter capable of exceeding 400 mph (644 km/h)—and it achieved some success in intercepting Fw 190s engaged in low-altitude high-speed intrusions over the United Kingdom which could not be countered by Spitfires.

The Typhoon's low-altitude potential was not to be fully exploited, however, until it was fitted with bombs and rockets and employed as a ground attack fighter a task in which it excelled, being transformed from a fighter of dubious reliability into a highly potent weapon that turned the scales in several land battles and upset many land warfare concepts. Although production was to total 3,317, the Typhoon, in spite of its later successes, never completely recovered from its early vicissitudes.

SPECIFICATION: Typhoon IB

Power Plant: One Napier Sabre IIA 24-cylinder H-type liquid-cooled engine rated at 2 180 hp at 3,850 rpm for take-off and 1,850 hp at 11,500 ft (3 505 m). Three- or four-bladed de Havilland Hydromatic constant-speed propeller. Internal fuel capacity 150 Imp gal (682 l) with provision for two 45 Imp gal (205 l) drop tanks.

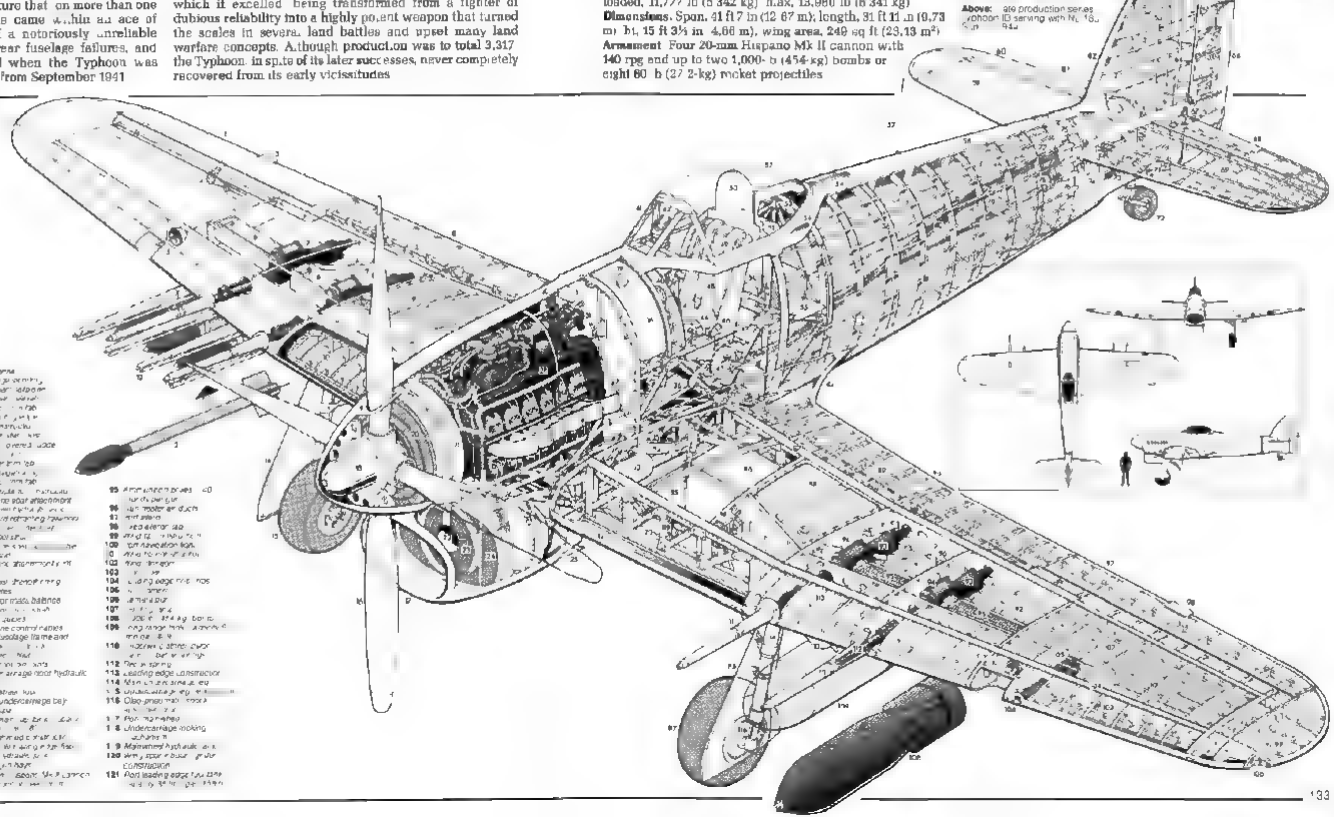
Performance: Max speed 405 mph (652 km/h) at 18,000 ft (5 485 m), 374 mph (602 km/h) at 5,500 ft (1 675 m); econ cruise, 354 mph (569 km/h) at 15,000 ft (4 570 m); range internal fuel, 610 mls (982 km), (with drop tanks), 1,000 mls (1 610 km), (with max external ordnance), 510 mls (821 km); time to 15,000 ft (4 570 m), 6·2 min; service ceiling, 34,000 ft (10 363 m).

Weights: Empty equipped, 9,800 lb (4 445 kg); normal loaded, 11,777 lb (5 342 kg); max, 13,980 lb (6 341 kg).

Dimensions: Span, 41 ft 7 in (12 67 m); length, 31 ft 11 in (9,73 m); ht, 15 ft 3½ in (4,66 m); wing area, 249 sq ft (23,13 m²).

Armament: Four 20-mm Hispano Mk II cannon with 140 rpg and up to two 1,000-lb (454-kg) bombs or eight 60-lb (27 2-kg) rocket projectiles.

Above: late production series Typhoon IB serving with No. 18[illegible] Sqn, 1944



Mikoyan-Gurevich MiG-3 (April 1940)

First in the generation of single-seat fighters evolving immediately prior to WWII to be optimised for high-altitude interceptor, the MiG-3 was small, heavy and very fast. Its speed capability was counterbalanced, however, by poor longitudinal stability and sluggish control response under virtually all conditions, poor spinning characteristics and a proclivity for spinning out of tight turns, sluggish manoeuvrability, for taxiying and take-off, and a dauntingly high landing speed – defects compounded by inadequate firepower and endurance.

Conceptual development began late in 1938 as Project K with the designation I-200 assigned to two prototypes. Artem Mikoyan and Mikhail Gurevich. Speed at altitude took priority over all other capabilities, the aim being to deliver the maximum practicable performance around the most powerful available liquid-cooled engine. With the concept defined, Mikoyan and Gurevich established an independent bureau and the first of three prototypes of the aircraft was flown on 5 April 1940.

The initial model, for which the Stalin Prize was awarded in which Nikolai Polikarpov shared, was designated MiG-1. Poor handling and unacceptably short range dictated major changes introduced with the 101st aircraft in February 1941, the designation of MiG-3 being simultaneously adopted. Fuel capacity was almost doubled but in the absence of fundamental redesign the changes made to improve flying qualities could be no more than palliative, the MiG-3 remaining a tiring aircraft to fly and one demanding a high degree of piloting skill.

Entering service in March 1941, no fewer than 1,289 MiG-3s had been completed by mid-year but they were soon found to be highly specialised in capability for the type of combat then ensued, this mostly taking place at lower altitudes than those at which the MiG-3 was designed to operate. This specialised interceptor was of a distinct disadvantage in fighter-versus-fighter combat. It had resulted from an incorrect assessment of the measure of the Luftwaffe's high-altitude bomber development programme, and the optimised warplane that took to the air was a luxury that the Soviet Union could ill afford at that time. Fortuitously, the AM-35A engine had to be withdrawn from production MiGs manufacture was being terminated by force majeure spring 1942. 3,422 having rolled off the assembly lines and assignment to less important sectors following from early 1943.

SPECIFICATION, MiG-3

Power Plant: One Mikulin AM-35A 12-cylinder vee liquid-cooled engine rated at 1,350 hp at 2,050 rpm for take-off, 1,230 hp at 19,685 ft (6,000 m) and 1,150 hp at 22,965 ft (7,000 m). VISh-61 Shch three-bladed constant-speed metal propeller. Internal fuel capacity, 114 Imp gal (519 l).

Performance: Max speed, 208 mph (480 km/h) at sea level, 325 mph (523 km/h) at 6,560 ft (2,000 m), 351 mph (565 km/h) at 13,125 ft (4,000 m), 368 mph (640 km/h) at 25,590 ft (7,800 m); max continuous cruise, 342 mph (550 km/h); range (max continuous cruise and 10% reserves), 510 mls (820 km); long range cruise, 342 mls (1,195 km); time to 16,400 ft (5,000 m), 5.7 min; ceiling, 38,370 ft (12,000 m).

Weights: Empty, 5,721 lb (2,595 kg); normal loaded, 7,385 lb (3,350 kg).

Dimensions: Span, 33 ft 5⅝ in (10.20 m); length, 27 ft 0¼ in (8.25 m); height (tail up), 12 ft 2½ in (3.72 m); wing area, 187.72 sq ft (17.44 m²).

Armament: One 12.7 mm Berezin UB machine gun with 300 rounds and two 7.62 mm Shpitalny-Komaritsky ShKAS machine guns with 375 (later 750) rpg.

Left: [illegible] of the [illegible] Fighter Aviation Regiment [illegible] Red Flag [illegible]

Left: A MiG-3 with cockpit canopy and radio mast removed, taking off on a combat mission near Leningrad during 1942.

Vought F4U Corsair (May 1940)

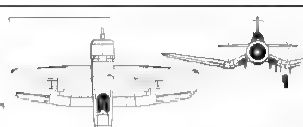
USA

Above A Corsair (Mk 1) of No 1830 Sqdn, the Royal Navy's first Corsair unit which pre-dated the US Marines' introduction in 1944

Of comparable appearance by virtue of a reverse-gulled wing – which resolved the clearance problem of the largest propeller ever used to that time by a fighter and kept the undercarriage within manageable length – the Corsair mated innovatory airframe design with the world's first 2 000 hp engine. Flown as a prototype XF4U-1 on 29 May 1940, the Corsair heralded a quantum advance in shipboard fighter capability as a result of the considerable ingenuity exercised by Rex B Beisel and his design team.

The production model flown on 21 June 1942 demonstrated a regrettable lack of shipboard finesse which was to exclude it from US carrier decks until the summer of 1944, although the Royal Navy, perhaps less fastidious than its US counterpart, was to clear the Corsair for shipboard operations nine months earlier. The Corsair suffered an incipient landing bounce and an almost unheralded torque stall in landing configuration, shortcomings compounded by some directional instability after touchdown. Its control harmony was poor, but its acceleration was dramatic in the cruise and at high speeds stability was positive at all times; it had a good range, adequate firepower, and great stress.

Shore based operations with the US Marine Corps began early in 1943 and it quickly fired success when flown from carriers, the Corsair established an enviable reputation from shore bases, production continuing until December 1952, by which time 7,829 had been delivered.



SPECIFICATION, F4U-1 Corsair

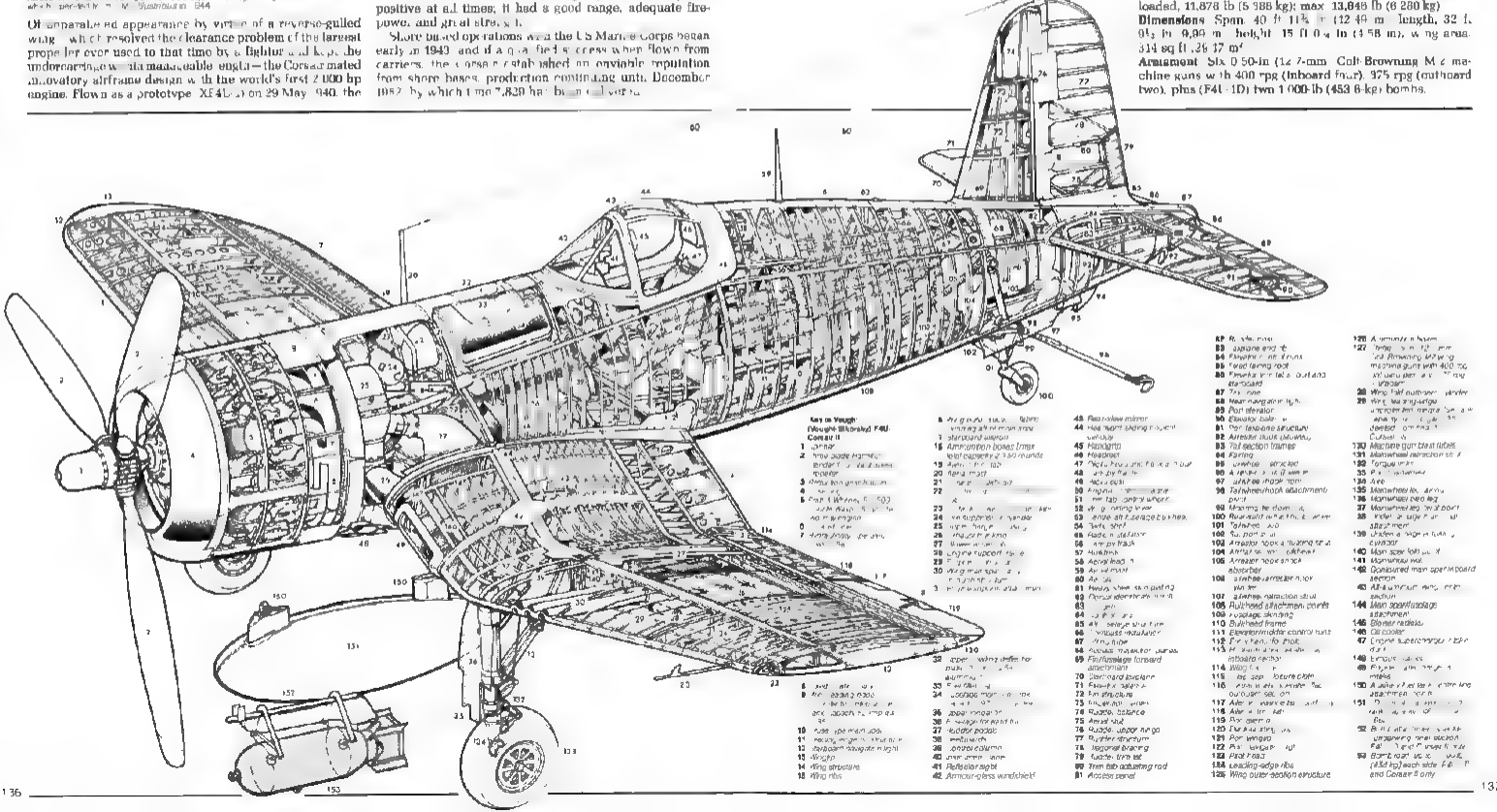
Power Plant: One Pratt & Whitney R 2800-8 Double Wasp 18-cylinder two-row radial air-cooled engine rated at 2 000 hp at 2,700 rpm for take-off and 1 875 hp at 2 500 ft (1 875 m). Three-bladed Hamilton Standard constant-speed propeller. Internal fuel capacity, 300 Imp gal (1 366 l), with provision for 146 Imp gal (662 l) centreline drop tank.

Performance: (At 11,878 lb (5 388 kg) Max speed, 320 mph (515 km/h) at sea level, 362 mph (631 km/h) at 24,000 ft (7 315 m); max range, 1,070 mls (1 722 km) at 177 mph (285 km/h) at 5,000 ft (1 525 m), (with max internal fuel and drop tank), 1,735 mls (2 792 km); time to 10,000 ft (3 050 m), 5 1 min, service ceiling, 37,000 ft (11 310 m)

Weights: Empty equipped, 8,873 lb (4 025 kg); normal loaded, 11,878 lb (5 388 kg); max, 13,848 lb (6 280 kg)

Dimensions: Span, 40 ft 11¾ in (12 49 m); length, 32 ft 8½ in (9,99 m); height, 15 ft 0¼ in (4 58 m); wing area, 314 sq ft (29 17 m²)

Armament Six 0 50-in (12 7-mm) Colt-Browning M 2 machine guns with 400 rpg (inboard four), 375 rpg (outboard two), plus (F4U-1D) two 1 000-lb (453 6-kg) bombs.



Key to Vought (Vought-Sikorsky) F4U-Corsair II

1 Spinner
2 Hub blade mechanism
3 Oil tank
4 Oil cooler
5 Engine (Pratt & Whitney R 2800 Double Wasp 18-cylinder air-cooled radial engine)
6 Engine mounting
7 Engine cowling
8 Air-cooling fan
9 Air-cooling cowling
10 Rudder pedal
11 Hydraulic reservoir
12 Instrument navigation light
13 Wing
14 Wing stringers
15 Wing ribs
16 Ammunition boxes (max total capacity 2 350 rounds)
17 Aerial mast
18 Aerial
19 Aerial mast
20 Aerial
21 Aerial
22 Aerial
23 Aerial
24 Aerial
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26 Aerial
27 Aerial
28 Aerial
29 Aerial
30 Aerial
31 Aerial
32 Upper wing skin for main fuel tank
33 Fuel filler
34 Upper wing skin
35 Fuel filler
36 Upper wing skin
37 Rudder pedal
38 Instrument
39 Rudder pedal
40 Instrument panel
41 Reflector sight
42 Armoured windscreen
43 Rear-view mirror
44 Hood hydraulic jacking mechanism
45 Handgrip
46 Headrest
47 Hood hydraulic jacking mechanism
48 Hydraulic
49 Hydraulic
50 Hydraulic
51 Hydraulic
52 Hydraulic
53 Hydraulic
54 Tank shell
55 Radio installation
56 Hydraulic
57 Hydraulic
58 Aerial lead
59 Aerial mast
60 Aerial
61 Heavy-duty wire
62 Fuselage
63 Fuselage
64 Fuselage
65 Fuselage
66 Fuselage
67 Fuselage
68 Fuselage
69 Fin/fuselage forward attachment
70 Starboard elevator
71 Elevator hinge
72 Fin ribs
73 Fin
74 Rudder
75 Aerial mast
76 Rudder
77 Rudder
78 Rudder
79 Rudder
80 Trim tab actuating rod
81 Access panel
82 Fuselage
83 Fuselage end
84 Fuselage
85 Fuselage
86 Fuselage
87 Tail cone
88 Rear navigation light
89 Port elevator
90 Elevator
91 Port tailplane structure
92 Arrester hook (retracted)
93 Tail section frames
94 Fairing
95 Tailplane structure
96 Fuselage
97 Fuselage
98 Tailplane/rudder attachment point
99 Mooring tie down
100 Rear wheel well
101 Tailplane
102 Suspension
103 Arrester hook actuating cylinder
104 Arrester hook
105 Arrester hook
106 Arrester hook shock absorber
107 Fuselage/arrester hook attachment
108 Fuselage reinforcing strut
109 Fuselage attachment points
110 Fuselage skin/ring
111 Fuselage frame
112 Elevator/rudder control hub
113 Fin ribs
114 Fuselage
115 Fuselage
116 Fuselage
117 Fuselage
118 Fuselage
119 Fin
120 Starboard wing
121 Port wing
122 Port wing
123 Pitot head
124 Leading-edge ribs
125 Wing outer-section structure
126 Aileron
127 Wing
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138 Wing
139 Wing
140 Main spar
141 Hydraulic
142 Combined main spar/inboard section
143 Aft spar/outer wing main section
144 Main spar/fuselage attachment
145 Starter radiator
146 Oil cooler
147 Engine supercharger intake duct
148 Engine
149 Engine
150 Aileron/flap control linkage attachment
151 Oil
152 Aft spar/inner wing section
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Reggiane Re 2001 Falco II (July 1940)

The fact that fighter capability enhancement was paced primarily by power plant availability was demonstrated in no country more profoundly than in Italy. Here in the late thirties, fighter development began to fall behind international standards through no lack of talent on the part of Italian practitioners of the art of fighter design, but through a manifest lack of engines capable of meeting the performance demands of the new generation of fighters.

The availability to the Italian fighter manufacturers of the excellent Daimler-Benz series of liquid-cooled engines radically transformed the situation, however and resulted in an interim generation of fighters. These essentially adaptations of existing designs to take advantage of the newly-available German engines, coupled the excellent handling characteristics and manoeuvrability of their progenitors with appreciably improved performances, raising Italian fighter standards once more to international levels.

Representative of this interim generation was the Re 2001 Falco (Falcon) II designed by Roberto G. Longhi and produced by the Reggiane subsidiary of the Caproni organisation as an adaptation of the radial-engined Re 2000, aerodynamically the most refined of pre-WWII Italian fighters. Flown mid-July 1940, the Re 2001 entered service late in 1941 (night fighter (Caccia Notturno) and fighter-bomber (Caccia Bombardiere) versions being produced. The Re 2001 retained the delightful flying qualities of the preceding Re 2000 but engine availability inhibited production and only 237 were to be delivered to the Regia Aeronautica.

SPECIFICATION Re 2001 Series I

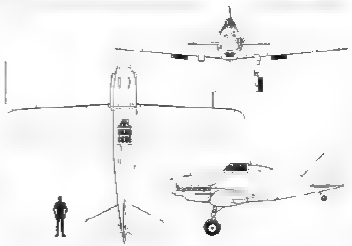
Power Plant: One Alfa Romeo R.A 1000 RC 41 Ia Monsonie (DB 601A) 12-cylinder inverted-vee liquid-cooled engine rated at 1,175 hp at 2,500 rpm for take-off and 1,100 hp at 12 140 ft (3 700 m). Three-bladed Alfa Romeo R.A 1000 constant-speed propeller. Internal fuel capacity, 119 85 Imp gal (544 l)

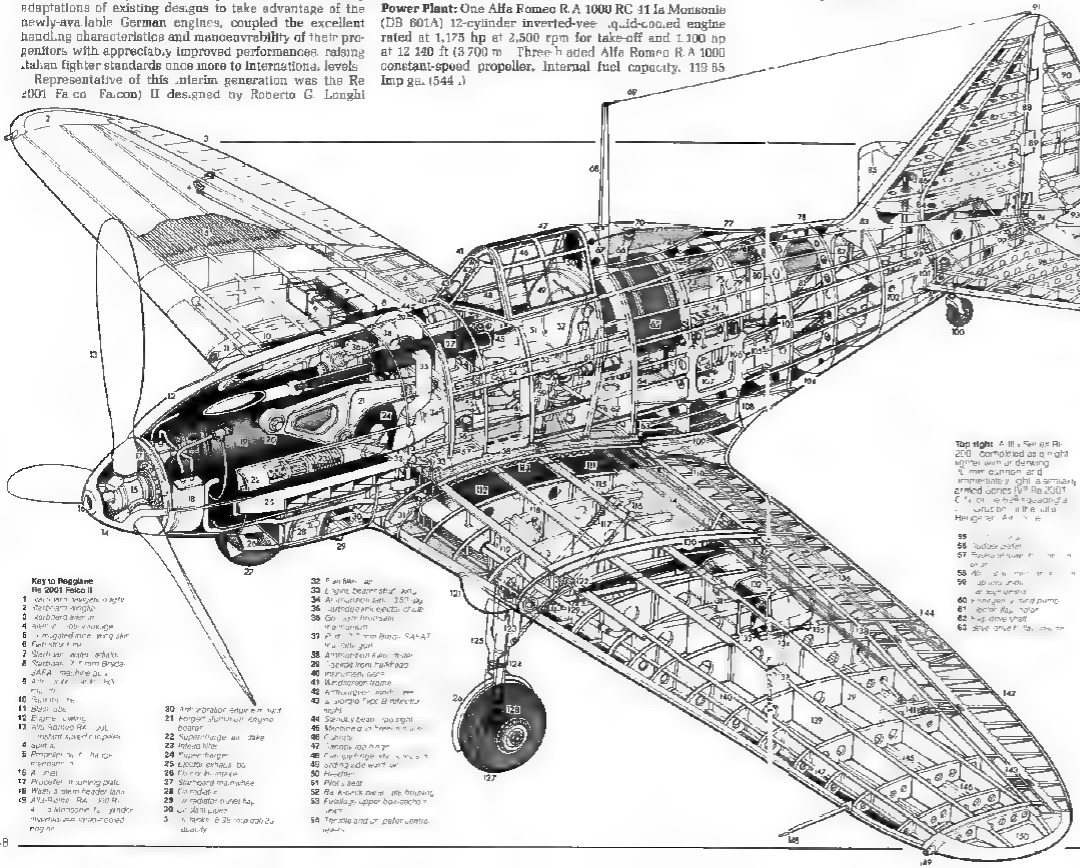
Performance: Max speed, 273 mph (440 km/h) at sea level, 320 mph (515 km/h) at 9 845 ft (3 000 m), 338 mph (545 km/h) at 17 945 ft (5 470 m); range 646 miles (1 040 km) at 233 mph (375 km/h) at 19 685 ft (6 000 m), 553 miles (890 km) at 273 mph (440 km/h) at 26 245 ft (8 000 m); time to 13 125 ft (4 000 m) 4·17 min, to 19 685 ft (6 000 m) 6·5 min; service ceiling, 39 205 ft (11 950 m)

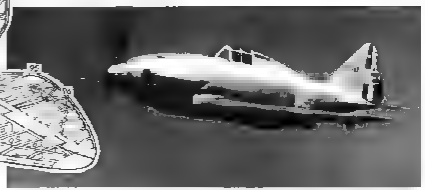
Weights: Empty equipped 5 265 lb (2 388 kg); loaded 6,988 lb (3 170 kg)

Dimensions: Span 36 ft 1 in (11.00 m), length, 27 ft 5½ in (8 36 m), height, 10 ft 2⅞ in (3 12 m); wing area 219 58 sq ft (20,40 m²)

Armament: Two 12 7-mm Breda-SAFAT machine guns with 350 rps, and two 7,7 mm Breda-SAFAT machine guns with 500 rps







Top right: Alfa Romeo Re 2001 Falco II modified as a night fighter with underwing gun pods, 7·7 mm guns and immediately right a German built Series I(R) Re 2001 [illegible]

Key to Reggiane Re 2001 Falco II

1 [illegible]
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12 Engine [illegible]
13 Alfa Romeo RA [illegible] radial engine cowling
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15 Propeller [illegible]
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17 Propeller [illegible]
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North American P-51 Mustang (October 1940)

Above: [illegible] the 343rd Fighter Sqdn, 55th Fighter Group, US [illegible] from Wormingford, Essex, 1944-45. The P-51D [illegible]

Fighter history demonstrates frequently, that service success does not necessarily equate with time expended on the drawing board, an outstanding case in point being the P-51. This was translated from outline concept to completed prototype within 122 days, yet was to emerge as arguably the best all-round single-seat piston-engined fighter of a WWII combatant.

Designed under the leadership of Raymond H. Rice and Edgar Schmued, and conceived in response to an RAF rather than USAAF requirement, the Mustang was an inspired design, an innovatory feature of which was the use of a low-drag laminar-flow aerofoil section. Flown (as the NA-73X) on 26 October 1940, the Mustang underwent very rapid genealogical processes, although its basic structure was subjected to no fundamental changes.

The initial model, known as the Mustang I to the RAF and P-51A to the USAAF was powered by a low-altitude Allison V-1710 engine which rendered it unsuited for the air-to-air role, since most combat took place above the altitude at which engine output began to fall off rapidly. The airframe proved readily amenable to installation of the Merlin, however, and this engine, with which it first flew on 13 October 1942, dramatically enhanced altitude performance, being adopted for the P-51B (Mustang III). A total of 15,367 was built. 7,956 of these were the P-51D model having a cut-down rear fuselage with all-round vision canopy.

SPECIFICATION P-51D Mustang

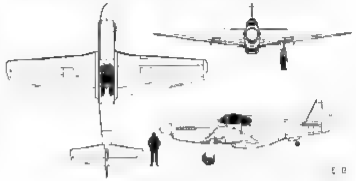
Power Plant: One Packard V-1650-7 (Merlin) 12-cylinder vee liquid-cooled engine rated at 1,450 hp at 3,000 rpm for take-off and 1,695 hp at 10,300 ft (3,140 m). Four-bladed Hamilton Standard constant-speed propeller. Internal fuel capacity 224 Imp gal. (1,018 l), and provision for two 62.5 or 91.5 Imp gal. (284 or 416 l) drop tanks.

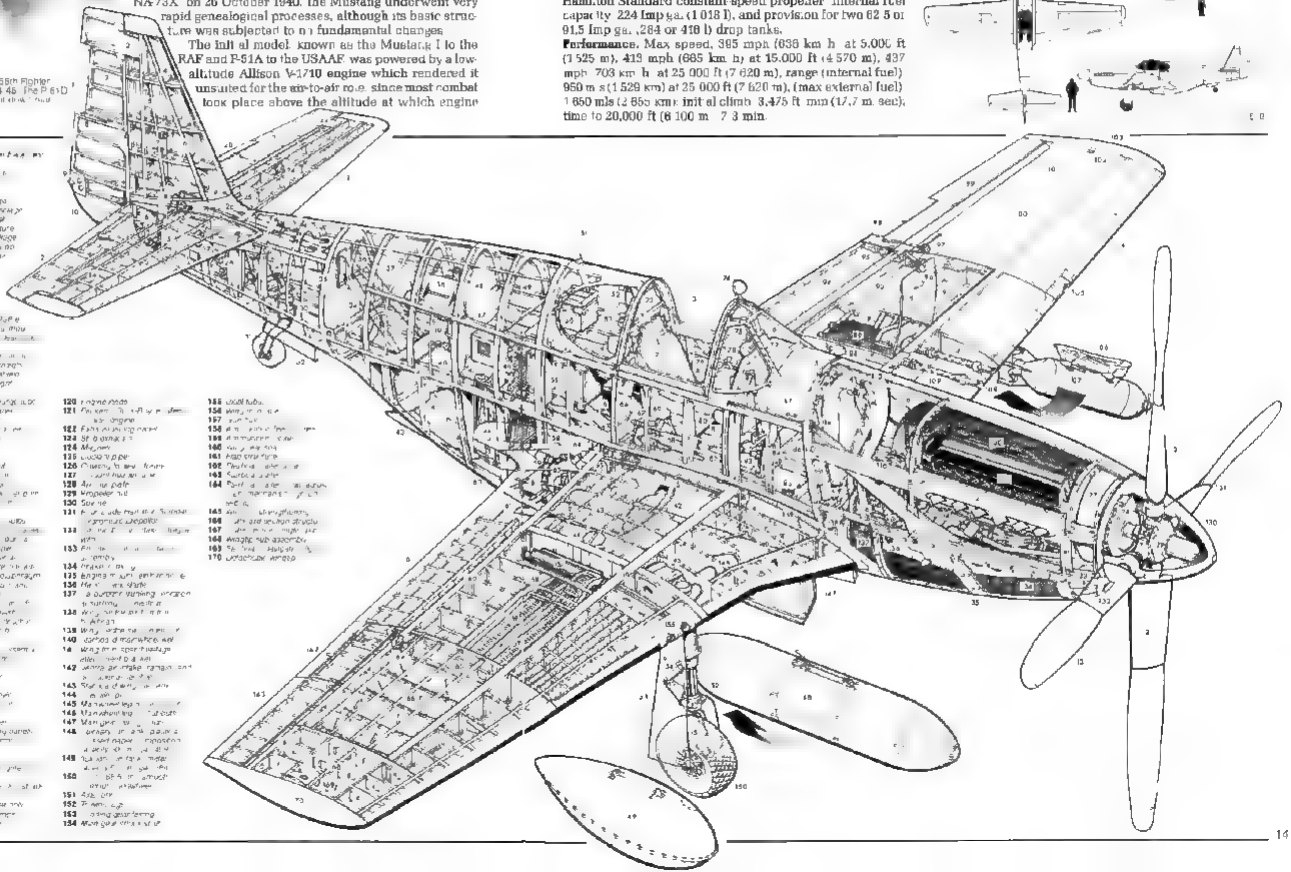
Performance. Max speed, 395 mph (636 km/h) at 5,000 ft (1,525 m), 413 mph (665 km/h) at 15,000 ft (4,570 m), 437 mph (703 km/h) at 25,000 ft (7,620 m), range (internal fuel) 950 m st (1,529 km) at 25,000 ft (7,620 m), (max external fuel) 1,650 mls (2,655 km); initial climb 3,475 ft/min (17.7 m/sec); time to 20,000 ft (6,100 m) 7.3 min.

Weights: Empty, 7,635 lb (3,463 kg), normal loaded 10,100 lb (4,580 kg); max 12,100 lb (5,490 kg).

Dimensions: Span 37 ft 0 in (11.28 m); length, 32 ft 3 in (9.83 m); height, 13 ft 8 in (4.16 m); wing area, 235 sq ft (21.83 m²).

Armament: Four 0.50-in (12.7-mm) Colt Browning machine guns with 400 rpg, or two with 400 rpg and four with 270 rpg. Provision for two bombs of up to 1,000 lb (454 kg) each plus (later aircraft) six 5-in (12.7-cm) rockets.





Key to North American P-51D Mustang

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De Havilland Mosquito (November 1940)

The Mosquito affords an example of that phenomenon rarely encountered in military aviation annals the warplane based on precepts directly contrary to those of officialdom and persisted with despite profound official scepticism. Radical in its initial concept as an unarmed bomber capable of out-flying all contemporary fighters the Mosquito was to find its true métier as a fighter. Indeed it was to become one of the most versatile fighters of WWII. Its prodigious repertoire spanning the spectrum from nocturnal intercept and intruder to diurnal long-range fighter-bomber and anti-shipping strike missions.

Ostensibly retrograde in utilising a wooden structure at a time when such were, by consensus, unequivocally superseded, the Mosquito was designed under the leadership of R.E. Bishop, and although devised as an unarmed bomber its fighter potential had been appreciated by the time that basic design was defined, sufficient space accordingly being provided beneath the cockpit for a battery of cannon. In fact, five months before the bomber prototype was to fly, on 25 November 1940, a prototype fighter was ordered, this flying on 15 May 1941.

Above: [illegible]

Differing from the bomber solely in having strengthened wing mainspar, a side door replacing a central entry hatch, armament, and AI Mk IV radar, with its characteristic 'arrowhead' aerials, the fighter entered service as the Mosquito NF Mk II in May 1942. Installation of centimetric AI Mk VIII radar or the US SCR 720 (AI Mk X) radar was to transform Mk II into Mks XII or (new-build) XIII and Mk XVII respectively, while success of the Mk II in the intruder role with radar deadest prompted the FB Mk VI, which fully realised the potential, of the Mosquito as a fighter-bomber, entering service in the first half of 1943. With a strengthened basic wing, the Mk VI carried four cannon and machine gun armament and up to 2,000 lb (907 kg) of ordnance.

The Mosquito, while at times demonstrating mild precocity in taking off and landing, was essentially a well bred aircraft with extremely pleasant flying characteristics. A grand total of 7,781 Mosquitoes was to be built, with the last leaving the assembly line in November 1950. Of these 1,134 were to be built in Canada and 212 in Australia, the fighter variants being by far the most prolifer ous, some 4,550 being completed as night fighters or fighter-bombers.

SPECIFICATION Mosquito F Mk II

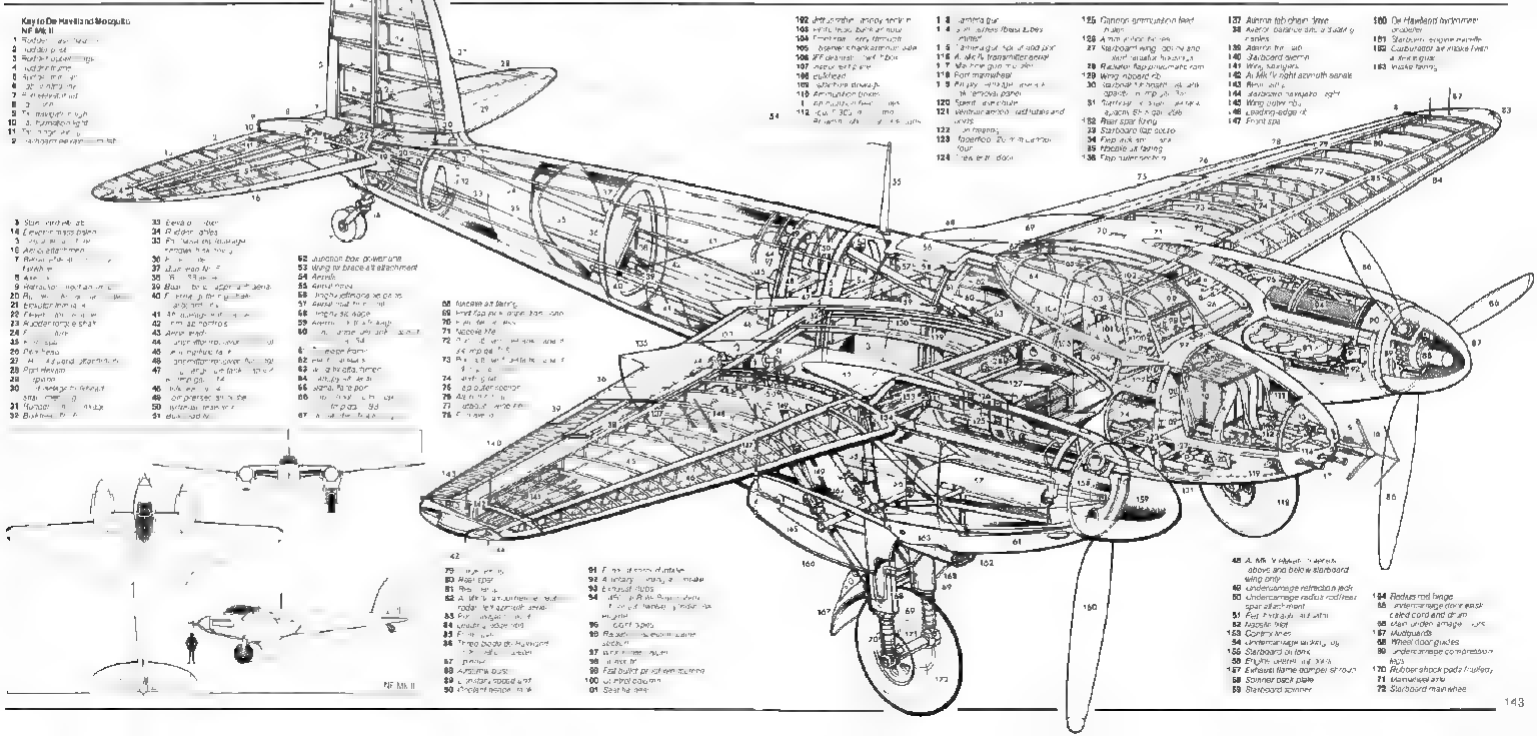
Power Plant Two Rolls-Royce Merlin 21 12-cylinder vee liquid-cooled engines each rated at 1,280 hp at 3,000 rpm for take-off and 1,480 hp at 12,250 ft (3,730 m). Three-bladed de Havilland constant-speed propellers. Internal fuel capacity 547 Imp gal. (2,487 l).

Performance: Max speed, 356 mph (573 km/h) at 9,000 ft (2,745 m), 370 mph (595 km/h) at 14,000 ft (4,265 m), max cruise, 265 mph (426 km/h) at sea level, 341 mph (549 km/h) at 20,000 ft (6,100 m), cruise range, 760-890 mls (1,255-1,432 km) according to altitude; time to 15,000 ft (4,570 m) 6.75 min, service ceiling 34,500 ft (10,515 m).

Weights Empty, 14,300 lb (6,490 kg), typical loaded 18,100 lb (8,210 kg), max. 20,000 lb (9,070 kg).

Dimensions: Span, 54 ft 2 in (16,51 m), length 40 ft 10 in (12,44 m), height 15 ft 3 in (4,65 m), wing area, 454 sq ft (42,18 m²).

Armament. Four 20-mm Hispano Mk I cannon with 150 rounds of ammunition for each gun and four 0.303-in (7,7 mm) Browning Mk II star machine guns with 500 rounds of ammunition for each gun.

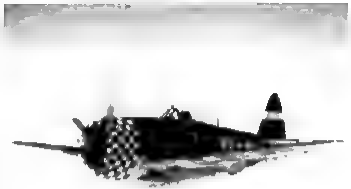


Republic P-47 Thunderbolt (May 1941)

Traditionally small and agile, the single-engined single-seat fighter took on an entirely new aspect with emergence of the P-47. By far the heaviest and largest such warplane created to that time, its great weight and generous proportions dwarfed all predecessors. While ostensibly an enlarged extrapolation of the less than successful P-43 Lancer, the P-47, designed by Alexander Kartveli, and flown (as the XP-47B) on 6 May 1941, was effectively conceived around a turbo-supercharger system. The lengthy, space-consuming ducting accepted in order to submerge the blower itself in the rear fuselage, together with the R 2800 engine and the chosen armament, governed its physical characteristics.

Weight and size inevitably evoked penalties. The climb rate was overly sedate, zoom capability poor and turning circle wide. Controls were light laterally but heavy fore and aft. It mushed in high speed turns, and stalled at any speed. It invariably snapped into a vicious spin. But the P-47 had been devised primarily as a high altitude bomber interceptor rather than a dogfighter, what it lacked in agility it compensated for with excellent altitude capability, formidable diving performance, extremely effective firepower and incredible sturdiness and ability to absorb damage.

Perhaps surprisingly, it was to find its true forte in the role of fighter-bomber. Of 15,683 P-47s manufactured, predominant was the D series of which 12,602 were built.



Above: A P-47 C-25-RA (Serial No 41-6140) of the 78th Fighter Group, based at Duxford, 1943. Note the 'Razorback' variant with bubble hood.

SPECIFICATION P-47D-30 Thunderbolt

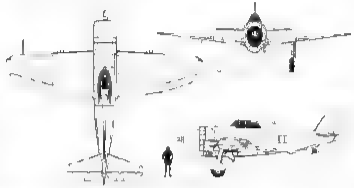
Power Plant: One Pratt & Whitney R-2800-59 Double Wasp 18-cylinder two-row air-cooled radial, engine rated at 2,000 hp at 2,700 rpm for take-off and 2,535 hp at 27,000 ft (8,230 m) with water-methanol injection. Four-bladed Curtiss Electric constant speed propeller. Internal fuel capacity 305 Imp gal (1,400 l) with provision for one 62.5 or 84.5 Imp gal (284 or 416 l) drop tank under the fuselage, and two 125 Imp gal (568 l) underwing drop tanks.

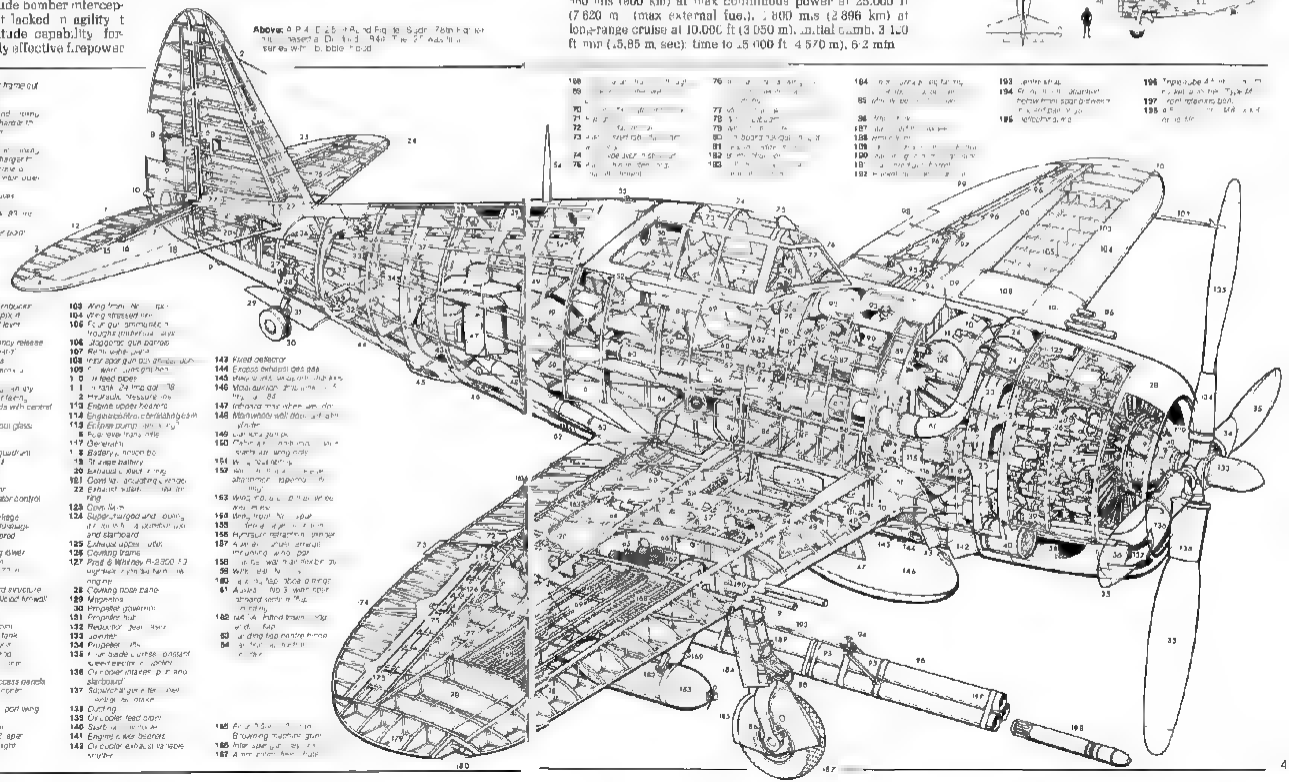
Performance: Max speed 303 mph (584 km/h) at 5,000 ft (1,525 m); 398 mph (640 km/h) at 15,000 ft (4,570 m); 426 mph (689 km/h) at 25,000 ft (7,620 m). Range (internal fuel) 550 mls (800 km) at max continuous power at 25,000 ft (7,620 m); (max external fuel) 1,800 mls (2,896 km) at long-range cruise at 10,000 ft (3,050 m). Initial climb 3,120 ft/min (15.85 m/sec); time to 25,000 ft (7,570 m) 6.2 min.

Weights: Empty 10,000 lb (4,540 kg); loaded 14,500 lb (6,580 kg); max 17,400 lb (7,890 kg).

Dimensions: Span 40 ft 9 in (12.42 m); length 36 ft 1 in (10.99 m); height 14 ft 7 in (4.44 m); wing area 300 sq ft.

Armament: Eight 0.50-in (12.7 mm) Colt-Browning machine guns with (normal) 267 or (max) 425 rpg. Provision for max bomb load of 2,500 lb (1,135 kg).





Key to Republic P-47D-10 Thunderbolt:

1 Rudder upper hinge
2 Aerial attachment
3 Fin fairing/aerial base
4 Rudder post/fin attachment
5 Fin aerial spar
6 Rudder trim tab and manual screw actuating mechanism
7 Rudder centre hinge
8 Rudder trim tab
9 Rudder structure
10 Tail navigation light
11 Elevator balance tab
12 Elevator trim tab
13 Tailplane/elevator structure
14 Elevator outboard hinge
15 Elevator trim tab
16 Elevator trim tab motor and screw actuating mechanism
17 Control drive
18 Tailwheel doorframe
19 Tail locking point
20 Rudder trim cables
21 Elevator control rod and linkage
22 Fin spar/fuselage attachment points
23 Fin structure
24 Aerial
25 Rear fuselage structure, the spars and flanged ribs
26 Tailwheel retraction motor and
27 Tailwheel with shimmy damper
28 Tailwheel leg
29 Tailwheel doors
30 Retractable aerial mast (lowered)
31 Tailwheel fork
32 Tailwheel shock and pivot
33 Rudder cables
34 Rudder and elevator trim control cables
35 Wing spar
36 Elevator control linkage
37 Semi-monocoque skin-stiffened fuselage construction
38 Fuselage frames, aerofoil profile
39 Aerial leads-in
40 Fuselage stringers
41 Supercharger filter
42 Supercharger
43 Turbo-supercharger
44 Supercharger exhaust
45 Turbo-supercharger exhaust to atmosphere, stainless steel
46 Water jacket
47 Supercharger exhaust
48 Exhaust ejector
49 Engine bearers
50 Microcooler and cooling and supercharger air
51 Radio transmitter and receiver racks, behind
52 Canopy track
53 Elevator rod linkage
54 Aerial mast
55 Aerial mast light
56 Windscreen frame and anti-icing plenum
57 Oxygen bottles
58 Supercharged and cooling air pipe, supercharger to air intake duct
59 Elevator linkage
60 Supercharger and cooling air pipe, supercharger to air intake, stainless
61 Aerial duct, 'D' shape cross section
62 Wing root air duct
63 Wing root fillet
64 Aerial/Aerial 28 mm gun sight
65 Air duct, top/bottom panel
66 Rudder cable turnbuckles
67 Tailplane/fin support
68 Seat adjustment lever
69 Hydraulic lines
70 Canopy emergency release jettisoning mechanism
71 Fuselage bulkheads
72 Seat and seat armour
73 Headrest
74 Rear spar
75 Rear view mirror fairing
76 Rear view windshields with central pillar
77 Internal bullet-proof glass screen
78 Canopy
79 Engine control quadrant, cockpit port wall
80 Control stick
81 Rudder pedals
82 Trigger, aileron control quadrant
83 Underfloor elevator control quadrant
84 Rudder cable linkage
85 Wing rear spar/fuselage attachment flanged connections
86 Wing supporting lower bulkhead section
87 Air flow pipe, 'D' shape cross section
88 Fuselage forward structure
89 Stainless steel 'Alclad' firewall, stiffened
90 Tank fill valve
91 Main fuel tank, cell
92 Aux fuselage fuel tank
93 Hydraulic reservoir
94 Aileron control rod
95 Aileron trim tab, inner actuators
96 Aileron hinge access panels
97 Aileron and aileron trim linkage
98 Aileron trim tab, port wing only
99 Fuel spar junction
100 Wing rear/fuselage spar
101 Port navigation light
102 Pitot head
103 Wing trim, port
104 Wing stressed skin
105 Port gun ammunition trough, port wing only
106 Jettisoning gun barrels
107 Port wheel well
108 Port gun ammunition chute
109 Port gun sight
110 Port flap
111 Port fuel tank (Imp gal 58)
112 Hydraulic pressure line
113 Engine upper fairing
114 Engine/cowling attachment beam
115 Engine pump, port only
116 Fuel level transmitter
117 Oil tank
118 Battery, port only
119 Starter battery
120 Exhaust stub, port only
121 Cowling, circumferential stringer
122 Exhaust stub, port only
123 Cowling
124 Supercharged and cooling air duct, 'D' shape cross section and starboard
125 Exhaust valve, port
126 Cowling frame
127 Pratt & Whitney R-2800-59 Double Wasp 18-cylinder two-row air-cooled radial engine
128 Cowling nose panel
129 Magneto
130 Propeller governor
131 Propeller hub
132 Reduction gear, front
133 Spinner
134 Propeller
135 Fuselage/wing/tail, port and starboard
136 Cowling/engine attachment points
137 Supercharger filter, port and starboard
138 Cowling
139 Oil cooler feed duct
140 Supercharger
141 Engine crankcase
142 Oil cooler exhaust stub, port
143 Fuel deflector
144 Engine exhaust gas stub
145 Wing root, port and starboard
146 Wing duct, port and starboard
147 Infrared navigation light
148 Windscreen wiper, port
149 Cockpit floor
150 Control rod, port
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Messerschmitt Me 163 (August 1941)

Conceptually certainly the most audacious fighter ever to achieve service status and remarkable for the number and variety of its innovations, the Me 163 was to claim unlikely in being the only manned warplane solely rocket powered to be deployed operationally. Other fighters similar in concept were to evolve, but none was to attain production and the rocket-driven interceptor, like the triplane fighter of WWI, was to prove merely an aberration from the mainstream of fighter evolution.

Conceived rather as a vehicle for transonic research than for a combat role, the Me 163 was designed by Dr Alexander M. Lippisch and no thought was given to operational potential until seven weeks after the first powered flight test (Me 163A V1) on 13 August 1941. The aircraft then underwent total redesign to adapt it as an interceptor, a role for which it was predestined by its high speed and phenomenal climb rate. No more than the basic configuration was retained and the first powered flight of the redesigned model (Me 163B V2) took place on 23 June 1943.

With a stressed-skin, light alloy semi-monocoque fuselage and plywood-covered wooden wings, the Me 163B relied on differentially-operated elevons for lateral and longitudinal control, taking-off with the aid of a jettisonable two-wheel dolly and landing on a centreline skid. Its handling and stability characteristics were good, control harmony being outstanding, but unless the CG was well forward, the stall was unheralded and abrupt, the port wing dropping sharply and a steep spiral dive ensuing. Considerable precision was necessary in taking off and even more so in landing, and operation of the Me 163B was rendered hazardous by the lethal propensities of its highly volatile rocket fuels.

The operational debut of the Me 163 was awaited with something akin to trepidation by RAF and USAAF alike. In the event this alarm was to prove unjustified owing to the shortcomings inherent in the basic operational concept of the rocket-propelled interceptor. Only 279 production aircraft were to be delivered and the service record of the Me 163B was to prove dismal. Its successes were few and 80 per cent of the losses that it sustained resulted from take-off or landing accidents, while 15 per cent were due to fire in the air or loss of control in a dive. Operations were limited by shortages of rocket fuel and trained pilots.

Above: [illegible] training and [illegible]

SPECIFICATION: Me 163B-1a

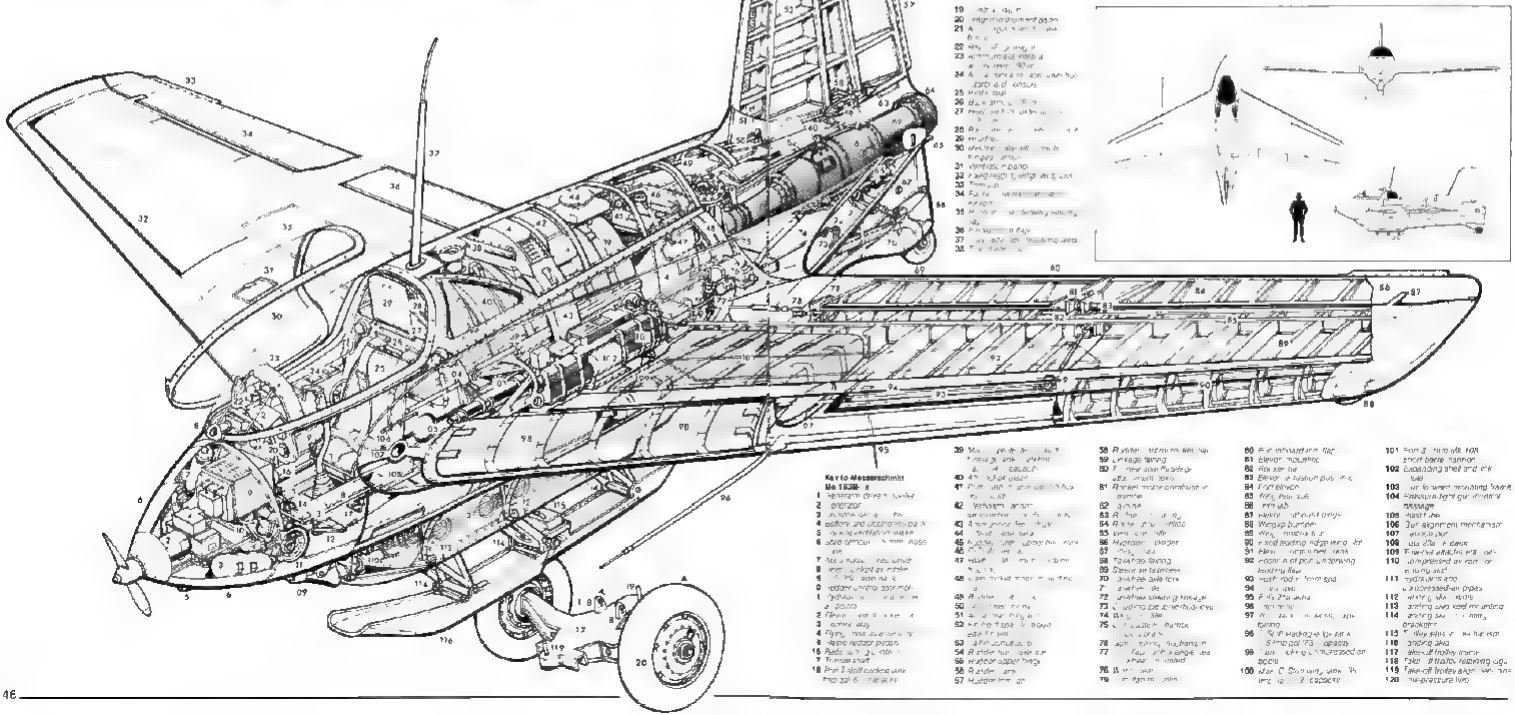
Power Plant: One Walter HWK 509A-1 or -2 bi-fuel rocket motor rated at 3 748 lb (1 700 kg) max thrust. Internal fuel capacity, 255 Imp gal (1 160 l) T stoff (hydrogen peroxide plus oxyquinoline) and 108 Imp gal (490 l) C stoff (hydrazine hydrate solution in methanol).

Performance: Max speed, 518 mph (830 km/h) at sea level, 593 mph (955 km/h) between 9,850 and 29,500 ft (3 000 and 9 000 m), max powered endurance 7.5 min, powered endurance after climb to 29,500 ft (9 000 m) at 497 mph (800 km/h), 2.5 min, normal radius of action, 22 mls (35.5 km); initial climb, 15,950 ft/min (81 m/sec), time to 29,500 ft (9 000 m), 2.5 min, to 39,370 ft (12 000 m), 3.35 min; service ceiling, 39,500 ft (12 040 m).

Weights: Empty equipped, 4 206 lb (1 908 kg); loaded, 9,502 lb (4 310 kg).

Dimensions: Span, 30 ft 7½ in (9.33 m); length 19 ft 2½ in (5.85 m); height (on dolly), 9 ft 0½ in (2.76 m); wing area, 199.13 sq ft (18.50 m²).

Armament: Two 30-mm Rheinmetal-Borsig MK 108 cannon with 60 rpg.



Key to Messerschmitt Me 163B-1a

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Kawasaki Ki.61 Hien (December 1941)

Above: Ki.61-I otsu fighters of the 244th Sentai based at Chofu, Tokyo Defence Area

The advent in Japanese Army service in 1943 of the Ki.61 Hien (Swallow) signified a radical change in fighter design thinking in Japan. It reflected the final rejection of the almost pathological belief in the paramountcy of agility above all else that previously dominated Japanese fighter evolution. Primarily as an outcome of analyses of combat with the Soviet I-16 over the Khalkin-Gol during the 'Nomonhan Incident' of 1939, level speed and climb and dive characteristics were accorded equal importance with manoeuvrability and some attention was finally given to firepower, self-sealing fuel tanks and pilot protection.

Designed by Takeo Doi and Shin Owada around the Daimler-Benz DB 601 engine, which had been adapted for Japanese manufacture, the Ki.61 was flown mid-December 1941. Although at first compared disparagingly by some Army pilots with the Ki.43 (see pages 124-125), which conformed more closely with established Japanese values, the Ki.61 was a thoroughly competent design from virtually every aspect. It retained a measure of traditional manoeuvrability combined with some of the better characteristics that prior to its debut were exclusive to western fighters.

What could not be flown with the abandon of the Ki.43 tending to stall and spin out to port with any overly violent use of the ailerons and rudder, the Ki.61 responded quickly and positively to smooth use of the controls and could hold its own in a dive against its heavier US adversaries. Appearing in combat over New Guinea in June 1943, it demanded some reassessment by the Allies of Japanese fighter capabilities and major rethinking of tactics once it was appreciated that it possessed attributes not found in its predecessors.

The initial Ki.61-I ko and otsu mounted machine gun armament, although 388 were re-armed with 20-mm MG 151 cannon—while the armament of the Ki.61-I-KA hei was more efficaceous, incorporating Ho-5 cannon. A total of 2,550 Ki.61-I fighters (including prototypes) was built, the intended successor, the Ki.61-II KAI with the more powerful but notoriously unreliable Ha-140 engine, failing to achieve service in any substantial quantity. More than any other type, the Hien dispelled the former widely-held belief among the Allies that all Japanese fighters were lightweights.

SPECIFICATION: Ki.61-I KAI hei Hien

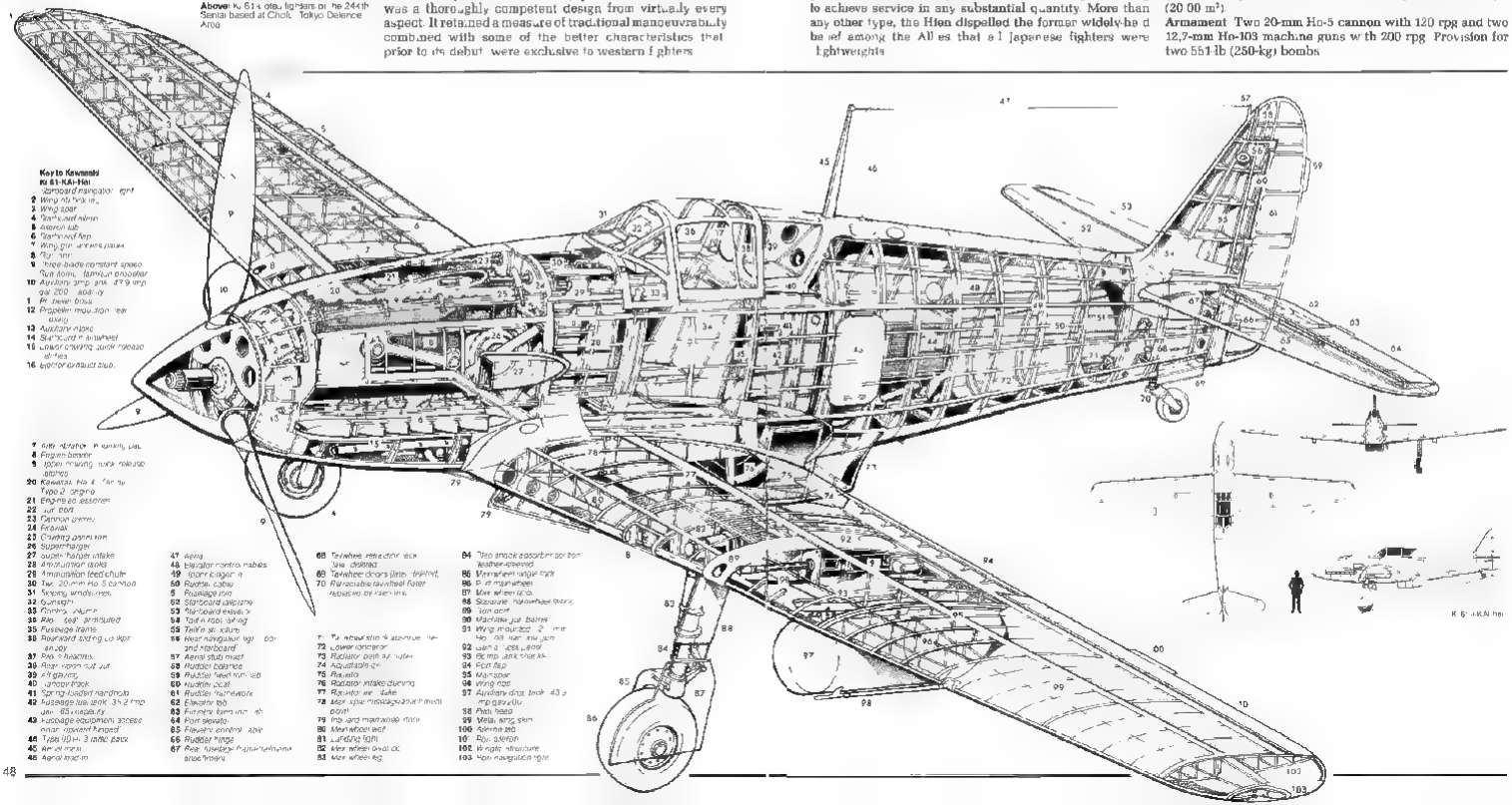
Power Plant: One Kawasaki Ha-40 (Army Type 2) 12-cylinder inverted-vee liquid-cooled engine rated at 1,175 hp at 2,500 rpm for take-off and 1,100 hp at 13,780 ft (4,200 m). Three-bladed Sumitomo constant-speed propeller. Internal fuel capacity 121 Imp gal (550 l) with provision for two 44 Imp gal (200 l) drop tanks

Performance: Max speed, 360 mph (580 km/h) at 16,405 ft (5,000 m); 302 mph (486 km/h) at sea level; normal cruise 242 mph (390 km/h) at 13,125 ft (4,000 m); range (internal fuel), 360 mls (580 km), (with drop tanks), 671 mls (1,080 km); time to 16,405 ft (5,000 m), 7·0 min; service ceiling, 32,810 ft (10,000 m)

Weights: Empty equipped, 5,798 lb (2,630 kg); normal loaded, 7,650 lb (3,470 kg)

Dimensions: Span, 39 ft 4½ in (12,00 m); length, 29 ft 2¾ in (8,94 m); height, 12 ft 1¾ in (3,70 m); wing area, 215·28 sq ft (20,00 m²)

Armament: Two 20-mm Ho-5 cannon with 120 rpg and two 12,7-mm Ho-103 machine guns with 200 rpg. Provision for two 551-lb (250-kg) bombs



Fairey Firefly (December 1941)

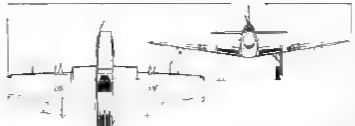
Carrying British two seat piston-engined shipboard fighter development to its apex, the Firefly synthesized its parent company's years of expertise in mating aeronautics, with nautical demands. Conceived as a multi-role aeroplane with emphasis on the Fleet fighter mission, it was to combine supreme versatility with ruggedness and reliability, coupling these attributes with a sound performance, good firepower and exceptional agility. It was to fulfil an unprecedentedly broad mission spectrum and this amenability was to result in a life span of a quarter of a century, during which it participated in two major wars.

While a very real advance in two-seat carrier fighters, the Firefly was essentially orthodox, its one really innovatory feature being its retractable Youngmann area-increasing flaps. With these at take-off setting, it could turn with the best of its single-seat contemporaries near the stall and turn inside most of them. Extended but undrooped, these flaps gave an invaluable lift increment in the circuit.

Superficially resembling the earlier Fulmar, the Firefly first flew on 22 December 1941, there being no prototype as such, and first equipped a squadron in October 1943, first production aeroplanes being F Mk I day fighters. The versatility of the design began to become apparent with the debut of night fighting, NF Mk I and fighter-reconnaissance FR Mk I versions, 140 of the former and 236 of the latter supplementing 459 straight day fighters.

In the Far East, its principal operational venue, the Firefly established an enviable reputation, and by the time WW II ended, extensive development was under way. The single-stage Griffon of the Mk I gave place to a two-stage engine, which, mated with wing leading-edge radiators, clipped wingtips and redesigned vertical tail, resulted in the more elegant Mk 4 flown on 25 May 1946. One hundred and sixty Mk 4s preceded serially similar Mks 5 and 6 which added anti-submarine warfare to their repertoire. 352 Mk 5s and 133 Mk 6s being built between January 1947 and September 1951, with power-folding wings replacing manual folding early in 1949.

Six squadrons of Mks 4 and 5 were involved in the Korean War, from 29 June 1950, when North Korean forces invaded the South, until the armistice of 27 July 1953. Production ended on 23 April 1956, when 1,702 Fireflies had been delivered.



SPECIFICATION, Firefly FR Mk 4

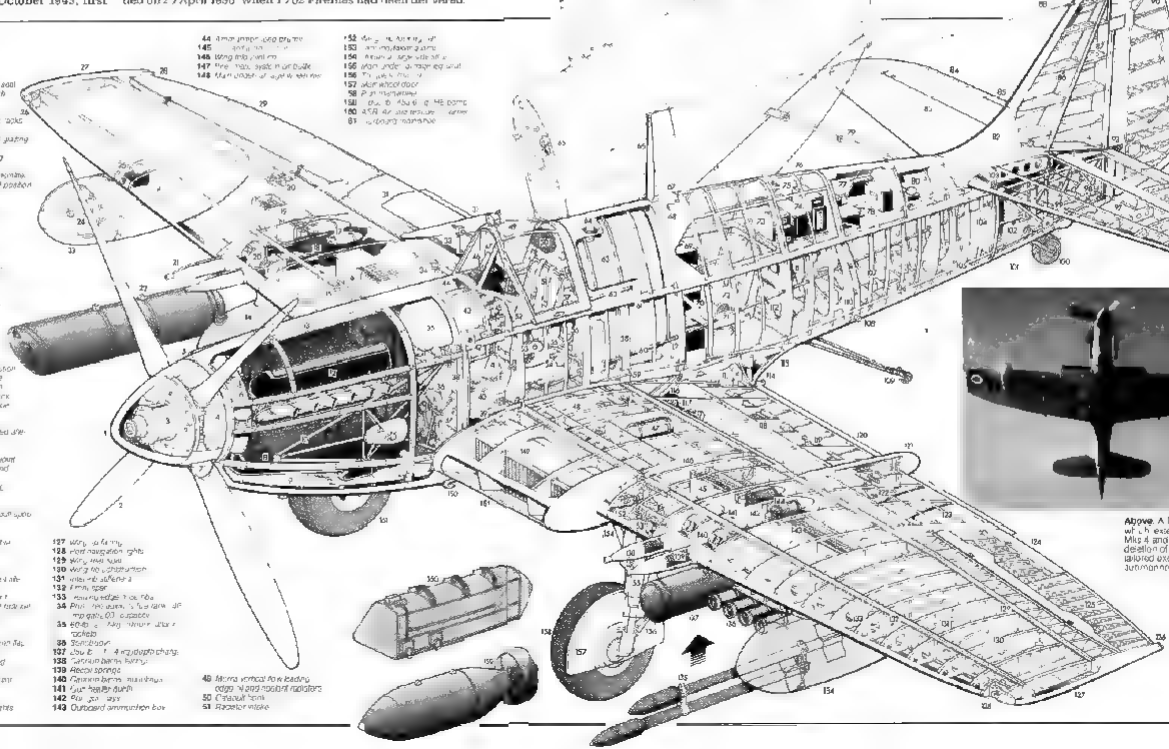
Power Plant: One Rolls-Royce Griffon 74 12-cylinder vee liquid-cooled engine rated at 2,004 hp at 2,750 rpm for take-off and 2,245 hp at 9,250 ft (2,820 m). Rotol four-bladed constant-speed propeller. Internal fuel capacity 200-5 Imp gal (911 l).

Performance: Max speed 316 mph (509 km/h) at sea level, 345 mph (555 km/h) at 12,500 ft (3,810 m); time to 5,000 ft (1,525 m), 3·6 min, to 10,000 ft (3,050 m), 7·15 min, range 582 mls (937 km) at 233 mph (375 km/h), with two 90 Imp gal (409 l) tanks, 1,070 mls (1,722 km) at 228 mph (367 km/h).

Weights: Empty equipped, 9,859 lb (4,472 kg); loaded 13,500 lb (6,124 kg), max 15,615 lb (7,083 kg).

Dimensions: Span, 41 ft 0 in (12·49 m), length, 37 ft 0 in (11·28 m), height, 15 ft 5½ in (4,74 m); wing area, 330 sq ft.

Armament: Four 20-mm Hispano cannon with 160 rpg and two 1,000-lb (453·6-kg) bombs, or eight 60-lb (27·2-kg) rockets, or eight 25-lb (11·34-kg) rockets and two 500-lb (227-kg) bombs.



Key to Fairey Firefly FR Mk 4

1 Spinner
2 Rotol four-bladed propeller
3 Propeller hub electro-charge mechanism
4 Spinner backplate
5 Ignition starting air intake
6 Coolant header tank
7 Supercharger air intake
8 Front engine mounting
9 Intake trunking
10 Engine bearer struts
11 Exhaust stacks
12 Rolls-Royce Griffon 74 vee 12-cylinder liquid-cooled engine
13 Detachable engine cowlings
14 Auxiliary oil tank, 30-Imp gal (136-l) capacity
15 Firewall, wing root attachments
16 Inboard ammunition box
17 Ammunition feed trunking
18 Hispano 20-mm cannon
19 Cannon barrel fairings
20 Cannon barrel mountings
21 Cannon barrel fairings
22 200-lb (453·6-kg) bomb
23 ASH radar housing
24 Radar scanner
25 Gun camera
26 Starboard wing root rib
27 Wing fairing
28 Formation keeping lights
29 Starboard aileron
30 Aileron trim tab
31 Fairey Youngmann flap (frame setting)
32 Flap hinge frame
33 Outboard flap hinge linkage
34 Rear spar wing fold hatch
35 Outboard flap actuating linkage
36 Main engine support frame
37 Engine control rods
38 Firewall bulkhead
39 Heater duct
40 Rudder pedals
41 Control column
42 Fuselage lifting eye attachment
43 Hydraulic fluid tank
44 Windscreen de-icing fluid tank
45 Instrument panel
46 Windscreen
47 Trim guillotine
48 Pilot's rear view mirror
49 Spring groups (actuating rods)
50 Headrest
51 Safety harness
52 Pilot's seat
53 The Rotol propeller
54 Cockpit spool release
55 Flap lever
56 Fire extinguisher
57 Thermos flask
58 Fuselage trunk frame
59 Wing spar attachment joint
60 Tailplane control quadrant
61 Cockpit floor longeron
62 Rudder stiffing
63 Main fuel tank, 118-Imp gal (536-l) capacity
64 Fuel filler cap
65 Starboard wing folded position
66 Aerial mast
67 Aerial cable lead-in
68 Air scoop
69 Radar crew rail
70 Radio racks
71 Radio tray
72 Observer's swivelling seat
73 Observer's entry hatch
74 Radio and electronics racks
75 Spare lamp
76 Observer's cockpit air glazing
77 Rear equipment bay
78 Rear fuselage stiffing
79 Wing spar carry through
80 Rear fuselage transverse frames
81 Tail unit fixed stowed position
82 Fin, port side
83 Tailplane trimmer
84 Starboard elevator
85 Elevator tab
86 Fin mounting
87 Stringers
88 Rudder tab
89 Rudder balance
90 Rudder control, rudder control jack
91 Rudder rib
92 Tail navigation lights
93 Rudder hinge frame
94 Elevator tab
95 Port elevator mass balance
96 Elevator horn balance
97 Tailplane construction
98 Tailplane mounting joint
99 Rear fuselage transverse frames
100 Rear fuselage stiffeners
101 Tailplane attachment joint
102 Tailplane bulkhead
103 Tailplane spar
104 Rear fuselage bulkhead
105 Bottom longeron
106 Aerial mast housing
107 Rear fuselage frame transverse
108 Detachable rear fuselage spool attachment
109 Jack stretcher hack
110 Rear fuselage double bulkhead
111 Spring fuses
112 Jack bunch tube
113 Trailing edge wing root rib
114 Mounting stud
115 Inboard flap hinge rib
116 Flap actuating mechanism
117 Wing fold hinge joint
118 Flap hydraulic motor cylinder
119 Aileron horn
120 Port Fairey Youngmann flap, inboard setting
121 Aileron hinge wing
122 Flap hinge linkage
123 Flap stress transverse joint
124 Port aileron tab
125 Aileron construction
126 Formation keeping lights
127 Wing outer rib
128 Wing navigation lights
129 Wing root rib
130 Wing fold attachment
131 Wing fold lifting
132 Aerial lead
133 Aerial mast fold hinge
134 Port 100-Imp gal (455-l) drop tank
135 Port 60-Imp gal (273-l) drop tank
136 Wing fold hinge joint
137 Wing fold lifting
138 Wing navigation lights
139 Wing root rib
140 Wing fold attachment
141 Wing fold lifting
142 Aerial lead
143 Outboard ammunition box
144 Aerial mast fold hinge
145 Wing root rib
146 Wing fold attachment
147 Wing fold lifting
148 Wing fold attachment
149 Wing root rib
150 Wing fold attachment
151 Wing fold lifting
152 Wing navigation lights
153 Wing root rib
154 Wing fold attachment
155 Wing root rib
156 Wing fold attachment
157 Wing stowed door
158 Port mainplane
159 Port 60-Imp gal (273-l) drop tank
160 Port 100-Imp gal (455-l) drop tank
161 Outboard mainplane
48 Mains vertical flow leading edge wing radiator radiators
50 Catapult hook
51 Radiator intake

Above. A Firefly AS Mk 6 which except for anti-sub warfare the Mks 4 and 5 apart from deletion of the wing guns, was tailored exclusively for anti-submarine operations.

Lavochkin La-5 (March 1942)

The mating with an air-cooled radial engine of a fighter airframe designed expressly for a liquid-cooled inline power plant as a result of *force majeure* has not been unknown. Without the redesign of fundamental components, however, few such enforced marriages have enjoyed success. One such metamorphosis that did prosper was the La-5 which was conceived as a result of re-engining the decidedly pedestrian LaGG-3 from the design bureau headed by Semyon A. Lavochkin.

The adaptation of the LaGG-3 airframe for the Shvetsov radial engine was the responsibility of Lavochkin's deputy S.M. Alekseyev, and the first conversion was flown successfully in March 1942. The reworking for the new power plant of all LaGG-3 airframes existing on the assembly lines commenced in July of that year, and production continued with new-build airframes featuring cut-down aft-fuselage decking and all-round vision canopy until late 1944. The M-82 of the La-5 and improved M-82F of the La-5F gave place from the end of March 1943 to the fuel-injection M-82FN (La-5FN) – FN standing for *Forsirovanny Nyeposredstvenny*, 'boosted engine' – which soon proved its worth during the crucial battle of Kursk, July-August 1943. A total of 9 920 La-5 fighters was manufactured.

The La-5 was, incidentally, the last single-seat fighter of wooden construction to see large-scale production and service. Its structure, inherited from the LaGG-3, employed a plastic-impregnated wood possessing special strength and fire-resistance properties, this being used in conjunction with bakelite ply (layers of birch strip bonded with bakelite film) for skinning. From the late spring of 1944, however, metal wing spars were introduced, these both saving weight and permitting a modest increase in internal fuel capacity.

The La-5 was a superlative low-to-medium altitude air superiority fighter, excelling in close-in high-g manoeuvring combat. Control was sensitive, climb-and-dive qualities were good, stall recovery was of a high order, turn rate was second to none and the aircraft could be looped and Immelmanned at low airspeeds. It did display some capriciousness during landing, however, demonstrating an incipient bounce and, if power was applied, frequently turning over.

Above: An example of the early production La-5 with the original M-82 engine, this being distinguished from the later La-5FN by the short supercharger air intake.

SPECIFICATION La-5FN

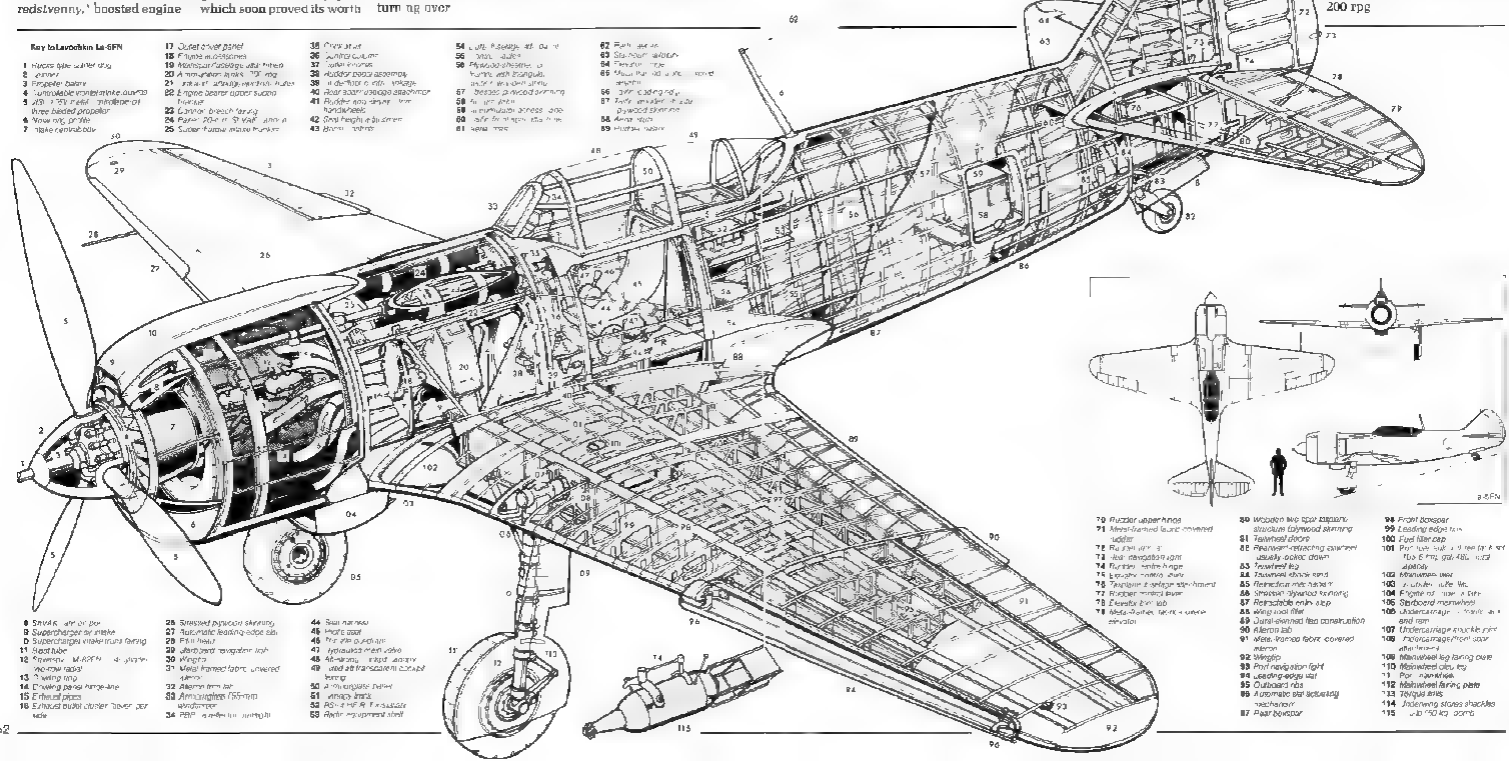
Power Plant: One Shvetsov M-82FN 14-cylinder two-row radial air-cooled engine rated at 1 850 hp at 2,500 rpm for take-off and 1,630 hp at 5 415 ft (1 650 m). Three-bladed VISh-105V constant-speed propeller. Internal fuel capacity, 77 Imp gal (350 l) with provision for two 14.3 Imp gal (65 l) internal overload tanks.

Performance: Max speed (at 7 100 lb/3 220 kg), 342 mph (550 km/h) at sea level, 380 mph (580 km/h) at 4 920 ft (1 500 m), 403 mph (648 km/h) at 20 670 ft (6 300 m); max range at econ cruise (with overload tank), 475 mls (765 km); time to 16 405 ft (5 000 m), 4·7 min; ceiling, 31,170 ft.

Weights: Empty equipped, 6 173 lb (2 800 kg); normal loaded, 7,407 lb (3 360 kg).

Dimensions: Span, 32 ft 1⅞ in (9.80 m); length, 28 ft 2⅝ in (8.60 m); height, 8 ft 4 in (2.54 m); wing area, 188 37 sq ft (17.50 m²).

Armament: Two 20-mm Shpitalny-Vladimirov ShVAK cannon with 200 rpg.



Key to Lavochkin La-5FN

1 [illegible]
2 Spinner
3 Propeller [illegible]
4 Controllable [illegible] intake louvres
5 VISh-105V metal [illegible] three-bladed propeller
6 Nose ring [illegible]
7 Intake centre body
8 Shield, [illegible]
9 Supercharger air intake
10 Supercharger intake trunk fairing
11 [illegible]
12 Shvetsov M-82FN 14-cylinder two-row radial
13 [illegible] strip
14 [illegible] hinge line
15 Exhaust pipes
16 Exhaust outlet cluster (seven per side)
17 Outer cover panel
18 Engine accessories
19 [illegible]
20 Ammunition boxes (200 rpg)
21 [illegible]
22 Engine bearer [illegible] frame
23 Cannon breech fairing
24 Paired 20-mm ShVAK cannon
25 [illegible] intake trunking
26 Stressed plywood skinning
27 Automatic leading-edge slats
28 Pitot head
29 Starboard navigation light
30 Wingtip
31 Metal framed fabric covered aileron
32 Aileron trim tab
33 Armourglass (55-mm) windscreen
34 PBP-1 reflector gunsight
35 [illegible]
36 [illegible]
37 [illegible]
38 Rudder pedal assembly
39 [illegible]
40 [illegible]
41 Rudder and [illegible] trim handwheels
42 [illegible] height [illegible]
43 [illegible]
44 Seat harness
45 [illegible]
46 [illegible]
47 [illegible] main valve
48 Armoured [illegible]
49 [illegible] transparent cockpit fairing
50 [illegible]
51 [illegible]
52 RSI-4 HF R/T [illegible]
53 Radio equipment shelf
54 [illegible]
55 [illegible]
56 [illegible]
57 [illegible] plywood skinning
58 [illegible]
59 [illegible]
60 [illegible]
61 [illegible]
62 [illegible]
63 [illegible]
64 [illegible]
65 [illegible]
66 [illegible]
67 [illegible] plywood [illegible]
68 Aerial mast
69 [illegible]
70 Rudder upper hinge
71 Metal-framed fabric-covered rudder
72 Rudder trim tab
73 [illegible]
74 Rudder centre hinge
75 [illegible]
76 Tailplane [illegible]
77 Rudder control lever
78 Elevator trim tab
79 [illegible] elevator
80 Wooden [illegible] structure (plywood skinning)
81 Tailwheel doors
82 Rearward-retracting tailwheel
83 Tailwheel leg
84 Tailwheel shock strut
85 Retraction mechanism
86 [illegible]
87 Retractable [illegible]
88 Wing root fillet
89 Dural-skinned flap construction
90 Aileron tab
91 Metal-framed fabric-covered aileron
92 Wingtip
93 Port navigation light
94 Leading-edge slat
95 Outboard ribs
96 Automatic slat actuating mechanism
97 Rear [illegible]
98 Front [illegible]
99 Leading edge [illegible]
100 Fuel filler cap
101 Port [illegible]
102 [illegible]
103 [illegible]
104 [illegible]
105 Starboard mainwheel
106 Undercarriage [illegible]
107 Undercarriage knuckle joint
108 [illegible]
109 Mainwheel leg fairing plate
110 Mainwheel oleo leg
111 Port mainwheel
112 Mainwheel fairing plate
113 Torque links
114 [illegible] stores shackles
115 [illegible] bomb

Messerschmitt Me 262 (March 1942)

One of the few truly epoch-making fighters in aviation's annals and arguably the most formidable warplane of WWII, the Me 262 launched a new era in aerial warfare. Such was its performance that, at the eleventh hour, it could have regained for the Luftwaffe some measure of ascendancy. Fortunately for the Allies, the Me 262 was plagued by vacillation and irresolution.

Despite its radical nature and even if marginally underpowered, the Me 262 was a pilot's aeroplane and in many respects easier to fly than the piston-engined Bf 109G. Responsive and docile with pleasant harmony of controls, it enjoyed a marked speed advantage over every contemporary. Aileron control at all attitudes was effective, stalling characteristics were good and it was able to turn as tightly as piston-engined opponents around the speed in tight turns for much longer. It was demanding on runway length, however and its pilot had to exercise care not to exceed limiting Mach number in a dive, while a low-speed flame-out of one of its temperamental turbojets was almost invariably disastrous. The Me 262 flew fairly well on one engine, but landing thus presented major problems.

Project studies for the Me 262 began as P 1065 in October 1938, when the intended power plant was still largely theoretical. Definitive configuration was not reached until May 1940, when increased engine weight at a late airframe design stage dictated wing sweep to compensate for the forward CG shift – at that time, the Messerschmitt team was unaware of the potential aerodynamic advantages of sweepback and it was thus largely fortuitous that the Me 262 became the world's first operational swept-wing fighter.

The first prototype, the Me 262 V1, flew on 18 April 1941 with a Jumo 210G piston engine, this being retained for initial flight with turbojets operating on 25 March 1942. The first flight on turbojets alone (Me 262 V3) took place three months later, on 18 July, and Luftwaffe acceptances of pre-series aircraft began in April 1944 with the first production aircraft following in June. The basic mode was the Me 262A-1a, a fighter-bomber variant being the Me 262A-2a. 513 being completed July-December 1944, and a further 865 following January-April 1945. Fuel shortages and inadequate pilot training largely nullified the Me 262's threat.

Above: The Me 262A-1a was a single-seat fighter-bomber variant of the Me 262 with a bomb rack under the fuselage for an SC 250 bomb or an equivalent load.

SPECIFICATION: Me 262A-1a

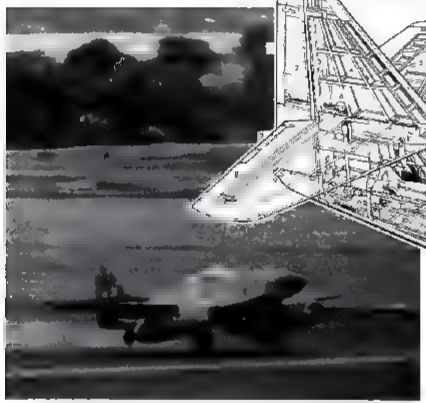
Power Plant: Two Junkers Jumo 004B-1 2 or 3 axial-flow turbojets each rated at 1,984 lb (900 kg) thrust. Max internal fuel capacity 365 Imp gal (2,570 l).

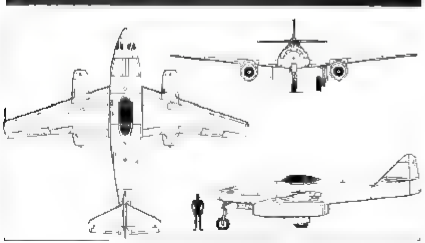
Performance: (At normal loaded weight) Max speed 534 mph (827 km/h) at sea level, 530 mph (853 km/h) at 9,840 ft (3,000 m), 540 mph (870 km/h) at 19,685 ft (6,000 m), 532 mph (856 km/h) at 26,245 ft (8,000 m), 510 mph (820 km/h) at 32,810 ft (10,000 m); range max, tanks only – 596 Imp gal (2,710 l), 296 miles (476 km) at sea level, 528 miles (850 km) at 19,685 ft (6,000 m), 652 miles (1,050 km) at 29,530 ft (9,000 m); initial climb, 3,939 ft/min (19.99 m/sec).

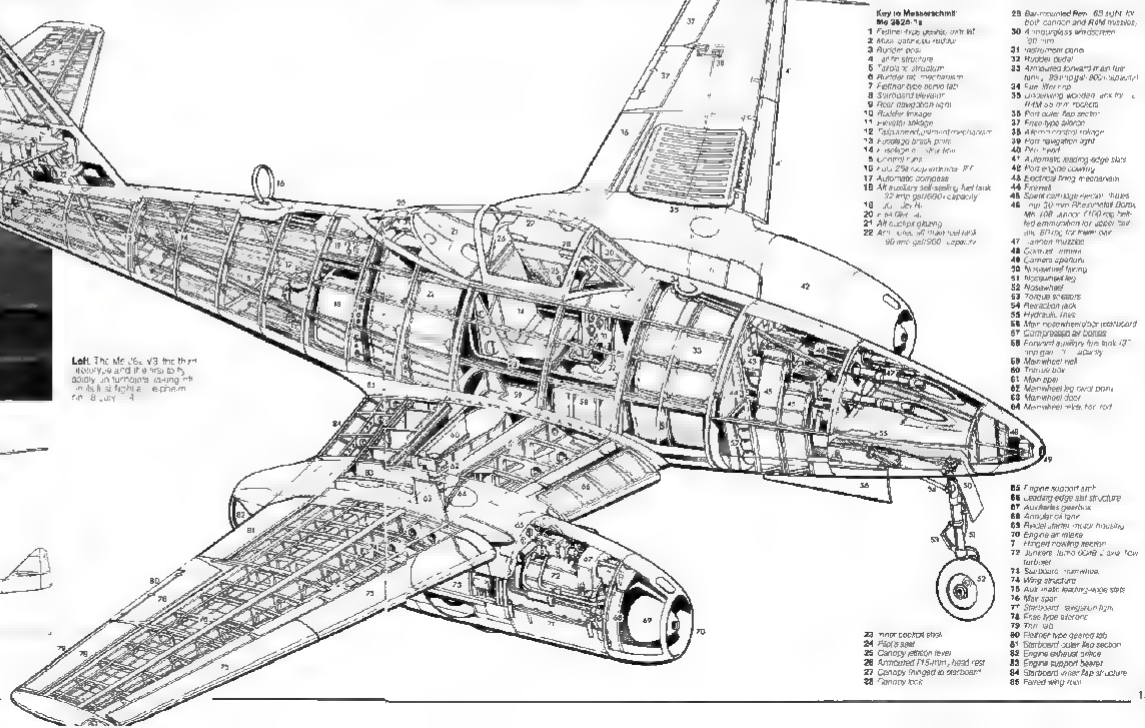
Weights: Empty 8,378 lb (3,800 kg), equipped 9,732 lb (4,420 kg), normal loaded (main tanks only) 14,101 lb (6,396 kg), (max internal fuel) 15,720 lb (7,130 kg).

Dimensions: Span 41 ft 0½ in (12.51 m), length 34 ft 9½ in (10.60 m), height 11 ft 6¾ in (3.52 m), wing area 233.58 sq ft (21.70 m²).

Armament: Four 30-mm Rheinmetal-Borsig MK 108 cannon with 100 rounds per gun for the upper pair and 80 rounds per gun for the lower pair.







Left: The Me 262 V3, the third prototype and the first to fly solely on turbojets, taking off on its first flight, at Leipheim on 18 July 1942.

Key to Messerschmitt Me 262A-1a

1 Pitot-tube pitot-static unit
2 Rear pitot-static tube
3 Rudder post
4 Fin structure
5 Tailplane structure
6 Rudder actuating mechanism
7 Fairing type pitot tube
8 Starboard tailplane
9 Rear navigation light
10 Rudder linkage
11 Elevator linkage
12 Tailplane/elevator actuating mechanism
13 Fuselage break point
14 Elevator actuating torque tube
15 Control rods
16 Fuselage structure
17 Automatic compass
18 Aft auxiliary self-sealing fuel tank (32 Imp gal/900 l capacity)
19 Jet pipe
20 Jet efflux
21 Aft fuselage plating
22 Aft fuselage self-sealing fuel tank (90 Imp gal/900 l capacity)
23 Inner pectoral step
24 Pilot's seat
25 Canopy emergency release
26 Armoured 15-mm head rest
27 Canopy hinged to starboard
28 Canopy lock
29 Bay-mounted Rheinmetal-Borsig 30-mm MK 108 cannon and 40-rd magazine
30 Armoured windscreen (80 mm)
31 Instrument panel
32 Rudder pedal
33 Armoured forward main fuel tank (84 Imp gal/380 l capacity)
34 Fuel filler cap
35 Outboard wing section, port, with 24 R4M 55-mm rockets
36 Port outer flap section
37 Fuselage pitot
38 Aileron control linkage
39 Port navigation light
40 Port aileron
41 Automatic leading-edge slats
42 Port aileron cowling
43 Electrical trim actuation
44 Fairing
45 Spent cartridge ejector chutes
46 Port 30-mm Rheinmetal-Borsig MK 108 cannon (100 rounds belt-fed ammunition for upper pair, 80 rounds for lower pair)
47 Cannon muzzles
48 Gun sight
49 Camera aperture
50 Nose-wheel fairing
51 Nose-wheel key
52 Nose-wheel
53 Torque stabiliser
54 Retraction jack
55 Hydraulic lines
56 Main undercarriage door actuator
57 Compressed air bottles
58 Forward auxiliary fuel tank (37 Imp gal/170 l capacity)
59 Main wheel well
60 Torque box
61 Main spar
62 Main wheel leg front pivot
63 Main wheel door
64 Main wheel strut foot
65 Engine support arch
66 Leading edge slat structure
67 Auxiliaries gearbox
68 Annular oil tank
69 Radial starter motor housing
70 Engine air intake
71 Hinged cowling section
72 Junkers Jumo 004B-2 axial-flow turbojet
73 Starboard nacelle
74 Wing structure
75 Automatic leading-edge slats
76 Main spar
77 Starboard navigation light
78 Fuse type aileron
79 Trim tab
80 Flapper type opened slat
81 Starboard outer flap section
82 Engine exhaust pipes
83 Engine support beams
84 Starboard inner flap structure
85 Faired wing root

Northrop P-61 Black Widow (May 1942)

Until the advent on operations in 1944 of the P-61, all fighters dedicated to the nocturne intercept task had been adaptations of aircraft designed primarily for other operational roles. The P-61 was thus unique at the time of its debut in being the first warplane designed from the outset for night fighting to achieve service status

As large as a medium bomber and possessing a crew of three comprising pilot gunner and radar operator the P-61 had its conception in a British rather than American requirement In 1940 British resources could not be stretched to the design and development of a fighter expressly for nocturne operation Thus, Northrop was approached with a British specification for a heavily-armed night fighter equipped with radar and capable of mounting standing patrols from dusk to dawn if necessary Before negotiations reached a decisive stage, however the US Army prepared a broadly similar specification and it was to this that the P-61 was developed the prototype (XP-61 flying on 26 May 1942

The P-61 embodied several innovatory features, the most novel of which was the use of the then-radical spoiler-type aileron permitting inclusion of near full-span flaps and thus expanding the speed range and permitting operation from comparatively small airfields Deliveries of the initial production model the P-61A commenced in October 1943 and, for an aircraft of its size and weight the P-61 proved remarkably manoeuvrable It could be looped Immelmanned slow-rolled or barrel-rolled and perform any other precision or semi-precision manoeuvre with ease. It could even be slow-rolled with one engine out in the direction of the dead engine It possessed an outstanding turn ability at speeds down to as low as 90 mph (145 km h), and the stall under any condition—power on, power off or asymmetric was straightforward with no tendency for a wing to drop

The P-61 achieved operational status almost simultaneously in both Europe and the Pacific in the early months of 1944 The P-61A was succeeded by the P-61B with minor but operationally important modifications, and the P-61C which introduced turbo-superchargers. When production terminated with the surrender of Japan in August 1945 a total of 706 P-61s had been delivered

Above: A P-61A 5 of the 422nd Night Fighter Squadron USAAF [illegible] in the summer of 1944 [illegible]

SPECIFICATION: P-61B-20 Black Widow

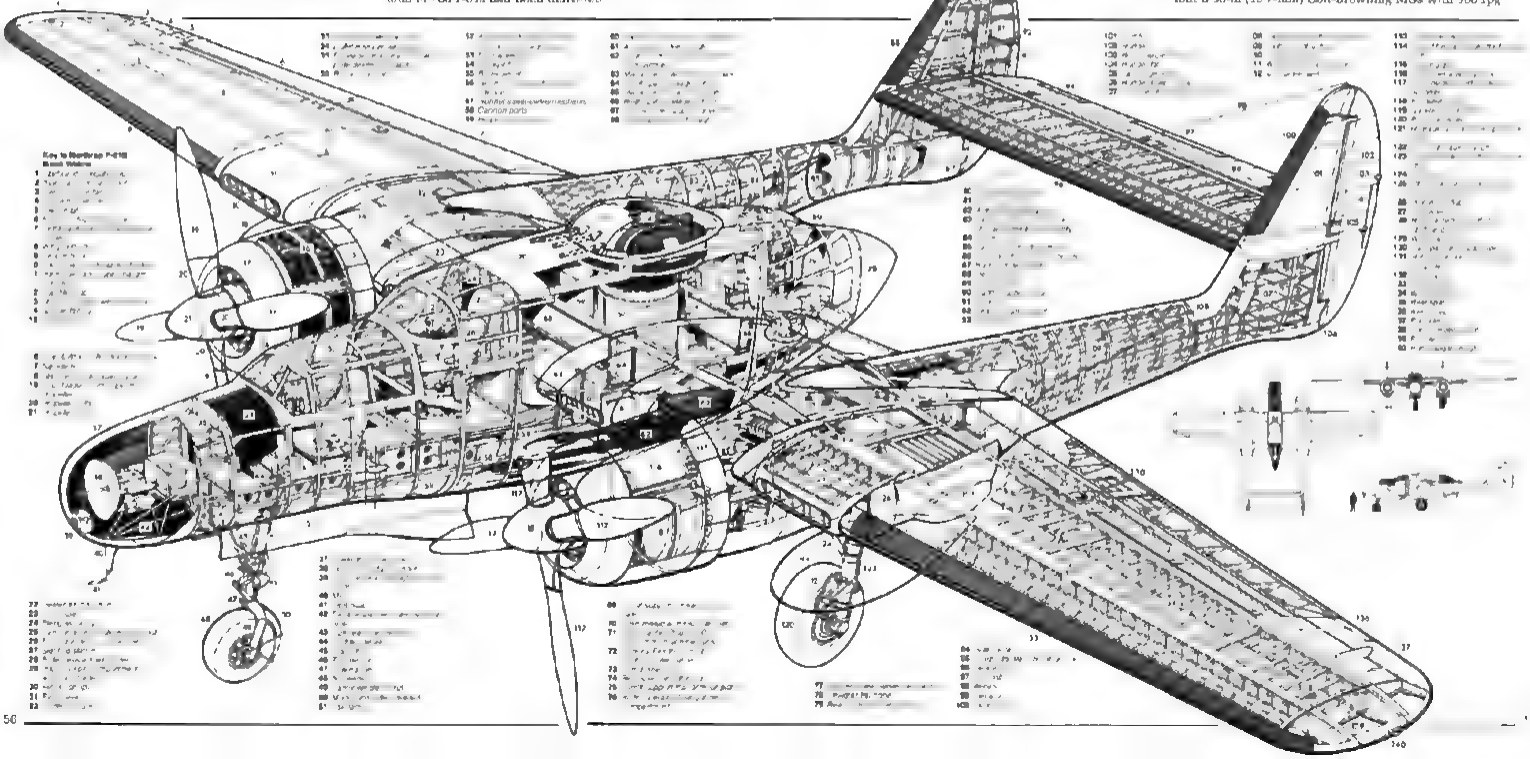
Power Plant: Two Pratt & Whitney R-2800-65 Double Wasp 18 cylinder two row radial air-cooled engines each rated at 1,850 hp at 2 700 rpm for take-off and 2 000 hp at 2,300 ft (700 m). Four-bladed Curtiss Electric propellers Internal fuel capacity 525 Imp gal (2 385 l) and provision for two or four 147 5 Imp gal (6,5 l) or 258 Imp gal (1 173 l) drop tanks

Performance: Max speed 330 mph (531 km h) at sea level 352 mph (566 km h) at 10,000 ft (3 050 m), 366 mph (589 km h) at 20,000 ft (6 100 m), range max continuous power) 550 mls (885 km) at 305 mph (491 km/h) at 10,000 ft (3 050 m), 810 mls (982 km) at 339 mph (545 km h) at 25,000 ft (7 620 m) initial climb, 2,550 ft min (12,9 m sec), time to 5 000 ft (1 525 m 2 7 min, to 10,000 ft (3 050 m), 5 8 min, to 15,000 ft (4 570 m), 8 8 min

Weights: Empty equipped, 23 450 lb (10 637 kg); normal loaded 29,700 lb (13 472 kg); max 36 200 lb (16 420 kg)

Dimensions: Span 66 ft 0¾ in (20 14 m), length 49 ft 7 in (15 11 m), height 14 ft 8 in (4,47 m); wing area 662 38 sq ft

Armament: Four 20-mm cannon with 200 rpg and (dorsal) four 0-50-in (12 7-mm) Colt-Browning MGs with 500 rpg



Grumman F6F Hellcat (June 1942)

USA

The inexorable growth in the size and weight of US Navy single-seat shipboard fighters that had begun its immediate upward spiral with the F4U Corsair (see pages 136-137) was to attain its apex for the single piston-engined warplane of this category with the appearance of the F6F Hellcat. Possessing the biggest wing of any single-seat fighter to see combat in WWII and weighing 60 per cent more than its predecessor the F4F Wildcat, the F6F was conceived primarily as an air superiority weapon with the range to seek out the enemy so that he could be brought to battle. It was the product of a design philosophy diametrically opposed to that pursued by the designers of its principal adversaries, in that agility and speed were not permitted to compromise structural strength, armour protection and firepower. It was thus not the fastest shipboard fighter of WWII, nor the most manoeuvrable, but it was undoubtedly the most efficacious.

The F6F was an astonishing fighter, not so much for its intrinsic qualities but for the rapidity of its translation from drawing board to operational deployment. No fighter of its era had a briefer gestation, none progressed from prototype test to squadron service within a shorter timespan. Designed by a team headed by Leroy R. Grumman and William T. Schwendler, the F6F was hurriedly conceived, engineered and manufactured, but it was to display no evidence of that haste. The contract for two prototypes had been placed on 30 June 1941, and a year later, on 26 June 1942 testing of the first prototype (XF6F-1) commenced. Within 14 weeks, on 9 October, the first production aircraft (F6F-3) was flown, the first US Navy squadron began to equip in January 1943, and fifteen squadrons were to be mounted on the fighter by the year's end, with a total of 2,555 F6F Hellcats then delivered.

The F6F could not manoeuvre with its Japanese adversaries, but it was faster, it could out-dive its opponents, it possessed superior firepower and it could withstand far more punishment. In flight the F6F was stable about all axes, although it displayed marked changes in directional and lateral trim with speed and power changes. It stalled with little warning and the drop of either wing, but recovery was straightforward, and the controls heavied up at high speeds until the introduction of spring tabs on the F6F-5 made rendered the ailerons light and effective throughout the speed range.

When production terminated in November 1945, no fewer than 12,275 F6F Hellcats had been manufactured and no fighter had done more to wrest aerial ascendancy over the Pacific from the Japanese.

SPECIFICATION F6F-3 Hellcat

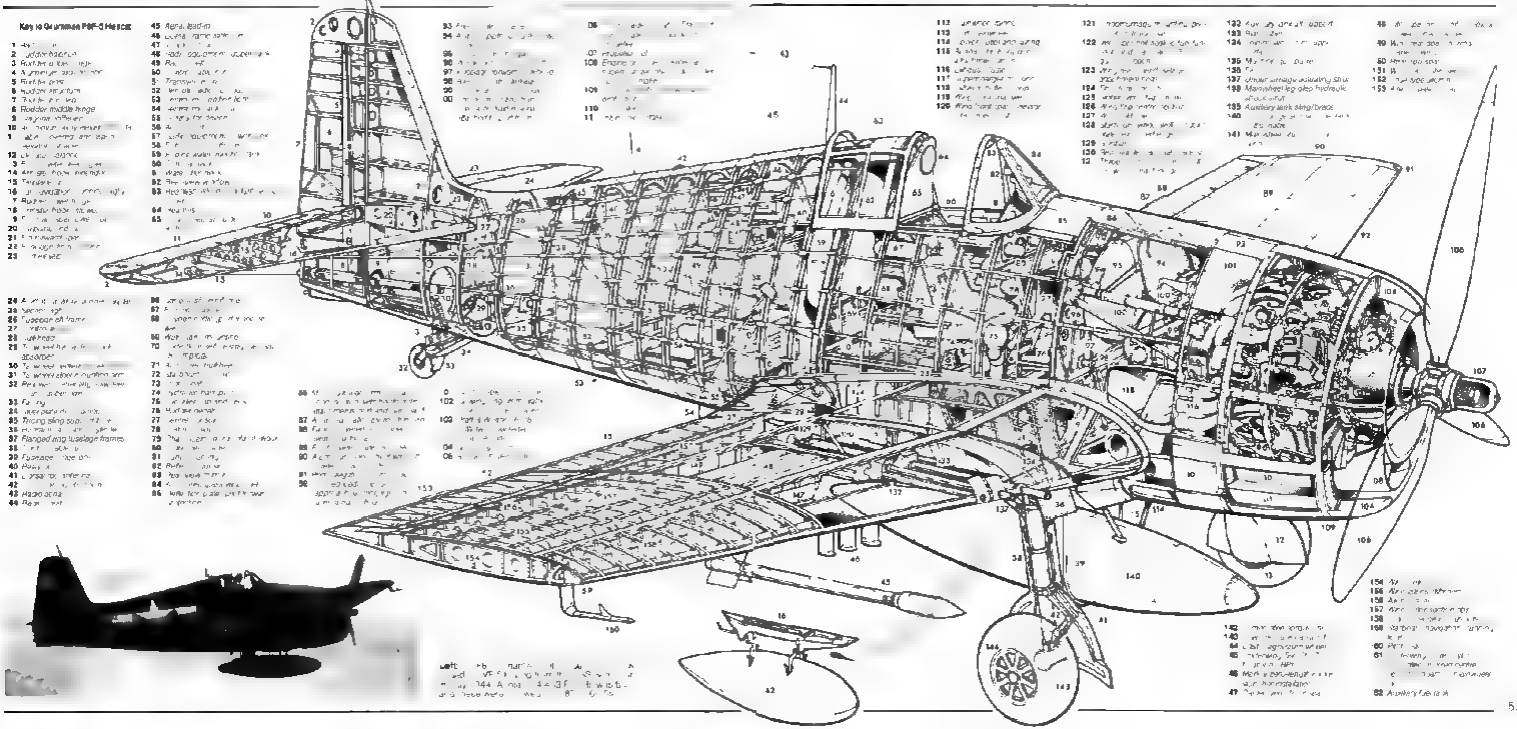
Power Plant: One Pratt & Whitney R-2800-10 Double Wasp 18-cylinder two-row radial air-cooled engine rated at 2,000 hp at 2,700 rpm for take-off and 1,800 hp at 15,700 ft (4,785 m). Three-bladed Hamilton Standard constant-speed propeller. Internal fuel capacity: 208 Imp gal (946 l), with provision for one 125 Imp gal (568 l) centreline drop tank.

Performance: (At 11,381 lb (5,162 kg) max speed: 324 mph (521 km/h) at sea level, 376 mph (605 km/h) at 22,800 ft (6,950 m), range (max internal fuel), 1,085 mls (1,746 km) at 173 mph (288 km/h) at 5,000 ft (1,525 m) (with drop tank), 1,630 mls (2,607 km) at 177 mph (285 km/h); initial climb, 3,650 ft/min (18.5 m/sec), time to 15,000 ft (4,570 m), 6·0 min, to 25,000 ft (7,620 m), 11·3 min; service ceiling, 35,500 ft (10,820 m).

Weights: Empty, 8,042 lb (4,101 kg); loaded, 12,186 lb (5,528 kg); max, 13,221 lb (5,997 kg).

Dimensions: Span, 42 ft 10 in (13·06 m); length, 33 ft 4 in (10·17 m); height, 14 ft 5 in (4·40 m); wing area, 334 sq ft.

Armament: Six 0·50-in (12·7 mm) Colt Browning machine guns with 400 rpg.



Yakovlev Yak-9 (July 1942)

No more astonishing an example of genealogical progression can be found in fighter development annals than that offered by the WWII fighter progeny of Alexander S Yakovlev. One fundamental fighter design of thoroughly orthodox concept and prosaic capability was to spawn, via a bewildering succession of nonpareil equipment, armament, engine and, eventually, structural changes, an entire *family* of combat aircraft, a family that was to provide in excess of 58 per cent of all fighters built in the Soviet Union during 1941-45.

Lightly armed, rudimentarily equipped and lacking refinements common to their western contemporaries, these fighters were deserving of respect nonetheless. Simple to build and to maintain under austere field conditions, they were ideally suited for the combat scenario to which they were committed, they were low-to-medium altitude fighters par excellence, their common virtues being good stability under all conditions and outstanding controllability at high attack angles.

From the basic Yak-1, phasing into service immediately prior to the German assault on the Soviet Union, two distinct lines of development emerged, albeit more by circumstance than intent. These were categorised as "heavy" and "light", the former materialising as the Yak-9 and the latter as the Yak-3 (see pages 166-167). The Yak-9 flew as the Yak-7DD in July 1942, appearing in small numbers operationally late in November. Subjected to a constant evolutionary process, the basic general-purpose "frontal" fighter was developed in several dedicated versions. These included the nocturnal intercept Yak-9PVO, the pinpoint bombing Yak-9B with internal bomb stowage and the anti-armour Yak-9T and -9K with 37 mm and 45 mm engine-mounted cannon respectively.

The Yak-9D featured increased internal fuel and the Yak-9DD was an even longer-ranging model for escort duties, while the late-war Yak-9U all-metal -9UT and post-WWII Yak-9P were to receive the more powerful M-107 engine. Production was to continue into the postwar years. 16 769 Yak-9 fighters in a variety of sub-types including 3 900 "third generation" Yak-9Us, having rolled off the assembly lines when manufacture finally terminated in 1947.

Above: Yak-9D [illegible] 1944

SPECIFICATION, Yak-9D

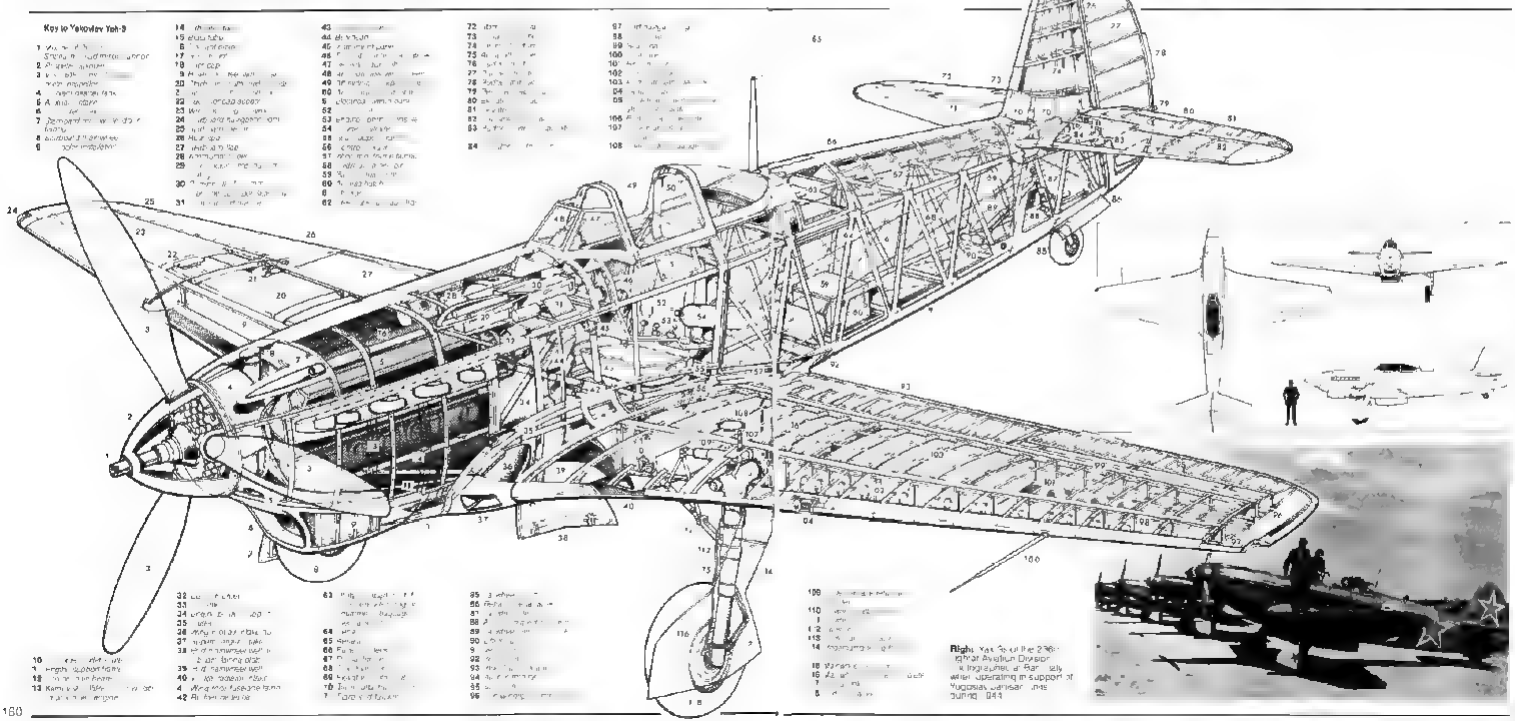
Power Plant: One Klimov M-105PF-3 12-cylinder vee liquid-cooled engine rated at 1,240 hp at 2 800 rpm for take-off and 1 360 hp at 2 625 ft (800 m). Three-bladed VISh-105SV constant speed propeller. Internal fuel capacity, 143 Imp gal (650 l).

Performance: Max speed, 332 mph (534 km/h) at sea level, 347 mph (558 km/h) at 3 280 ft (1 000 m), 354 mph (570 km/h) at 6,560 ft (2 000 m), 374 mph (602 km/h) at 10 170 ft (3 100 m); max range, 870 mls (1 400 km), at 366 mph (300 km/h); 733 mls (1 180 km) at 242 mph (390 km/h), 603 mls (970 km) at 264 mph (425 km/h); time to 16 405 ft (5 000 m), 6.0 min.

Weights: Empty equipped, 5,260 lb (2 390 kg); normal loaded, 6,867 lb (3 115 kg).

Dimensions: Span, 31 ft 11½ in (9.74 m); length, 28 ft 0¾ in (8.55 m); height (tail up), 9 ft 10 in (3.00 m); wing area, 184.6 sq ft (17.15 m²).

Armament: One 20 mm Shpitalny-Vladimirov ShVAK cannon with 120 rounds and one 12.7 mm Berezin UB machine gun with 180-220 rounds.



Right: Yak-9s of the 296th Fighter Aviation Division, a regiment of Partisans, seen operating in support of Yugoslav cavalry units during 1944

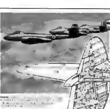
Gloster Meteor (March 1943)

Once the foundations for a technical breakthrough have been laid through pure research its practical application is frequently pursued independently and simultaneously in several countries. So it was with the aircraft gas turbine and its application to the fighter which developed into a race between Germany and Britain that the former won by a short head

Operations with the Me 262 (see pages 154-155) had just begun when, in July 1944 its British counterpart, the Meteor, made its RAF service debut Twelve prototypes, the first of which flew on 5 March 1943 were followed by 20 Meteor Is, but their 1,700 lb (771 kg) Welland turbojets were insufficiently powerful to realise the full airframe potential the 2,000 lb (907 kg) Derwent I being adopted for the initial series model, the Meteor III although the first 15 perforce kept the Welland flown September 1944.

Two hundred and ten Meteor IIIs were followed by the Derwent 5-powered F Mk 4, which, with strengthened airframe began to enter service in 1946 Unlike its German contemporary the Meteor was not a pilot's aeroplane in the traditional sense its faults were common enough among first-generation jet fighters. Controls were well balanced and reasonably effective but heavied up above Mach = 0·72 until they became almost "solid" coarse use of trimmers being necessary to produce any marked effect A strong nose-up trim change needed to be countered around Mach = 0·75 and became barely manageable at Mach = 0·82, while there was a tendency to snake at speed and the Meteor was handicapped in flying a pursuit curve above 460 mph (740 km/h) by its high aileron stick forces

The Meteor was, nevertheless arguably the most successful of western first-generation jet fighters. Early in the production run of 758 F Mk 4s, the wing span was reduced to provide a more acceptable roll rate, and, to improve somewhat inadequate directional stability, the fuselage of its successor, the F Mk 8 was lengthened. This variant entered service from 1950, 1,183 being built In first-line RAF service for 17 years, the Meteor was exported to a dozen countries, a total of 3,850 being built in all versions.



Above [illegible]

SPECIFICATION: Meteor F Mk 4

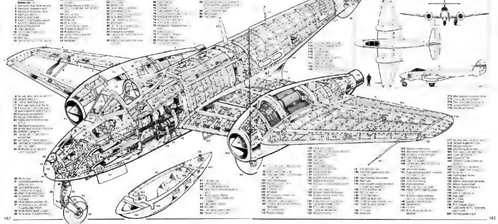
Power Plant: Two Rolls-Royce Derwent 5 centrifugal-flow turbojets each rated at 3 500 lb (1 588 kg). Internal fuel capacity 325 Imp gal (1 477 l), with provision for one 180 Imp gal (818 l) centreline and two 100 Imp gal (455 l) wing drop tanks

Performance: Max speed, 585 mph (941 km/h) at sea level, 570 mph (917 km/h) at 20 000 ft (6 100 m), max cruise, 540 mph (869 km/h) at sea level, 530 mph (853 km/h) at 30,000 ft (9 145 m), range (internal fuel), 420 mls (676 km) at 30,000 ft (9 145 m), (with centreline tank), 680 mls (1 094 km), (with max external fuel 1,000 mls (1 609 km) initial climb, 7 500 [illegible] to 30,000 ft (9 145 m) 5·0 min to 40,000 ft (12 190 m) 8·0 min

Weights: Empty 10,050 lb (4 558 kg) normal loaded 15,000 lb (6 804 kg) max 18,000 lb (8 165 kg)

Dimensions: Span 37 ft 2 in (11.33 m) length, 41 ft 0 in (12.50 m, height, 13 ft 0 in (3.96 m), wing area, 350 sq ft (32.51 m²)

Armament: Four 20-mm Hispano Mk II cannon with 195 rounds of ammunition for each cannon



Nakajima Ki.84 Hayate (April 1943)

Carrying Japanese WWII single-seat fighter evolution to its peak, the Ki.84 Hayate (Gale) mirrored the metamorphosis in Imperial Army offensive air superiority fighter demands that had taken place since introduction of the Ki.43 Hayabusa (see pages 124-125). The Ki.43 had featured a well-designed but decidedly lightly constructed airframe mated with a low-powered engine, rudimentary pilot and fuel tank protection, and the lightest of armament. The Ki.84 in dramatic contrast was characterised by an extremely robust structure with all the advantages of a really powerful engine utilising water-methanol injection, self-sealing fuel tanks, adequate pilot protection and a highly destructive armament.

Designed under the direction of Yasumi Koyama, the Ki.84 was flown during the first week of April 1943, within 11 months of the acceptance by the Army Air Headquarters of Nakajima's design study. No fewer than 83 service trials aircraft were built, largely by hand, and the first production example of the Ki.84-I ko (Type 4 Fighter Model 1-ko) was delivered in April 1944. Production rose quickly and widespread regimental service was rapidly achieved.

Although possessing somewhat temperamental ground handling characteristics, the Ki.84 displayed except onally tractable flying qualities, comparatively inexperienced pilots converting after the briefest of training. In common with most of its contemporaries the elevators tended to heavy up at high speeds and the rudder became somewhat mushy at low speeds, but in all other respects the Ki.84 offered superlative handling. It could out-climb and out-manoeuvre any adversary and it was never to be outclassed.

By the beginning of 1945 the Ki.84 had become the most numerous of Japanese Army fighters, and acceptances of this redoubtable warplane (both pre-production and production) were to total 3,470 aircraft.

SPECIFICATION Ki.84-I-ko Hayate

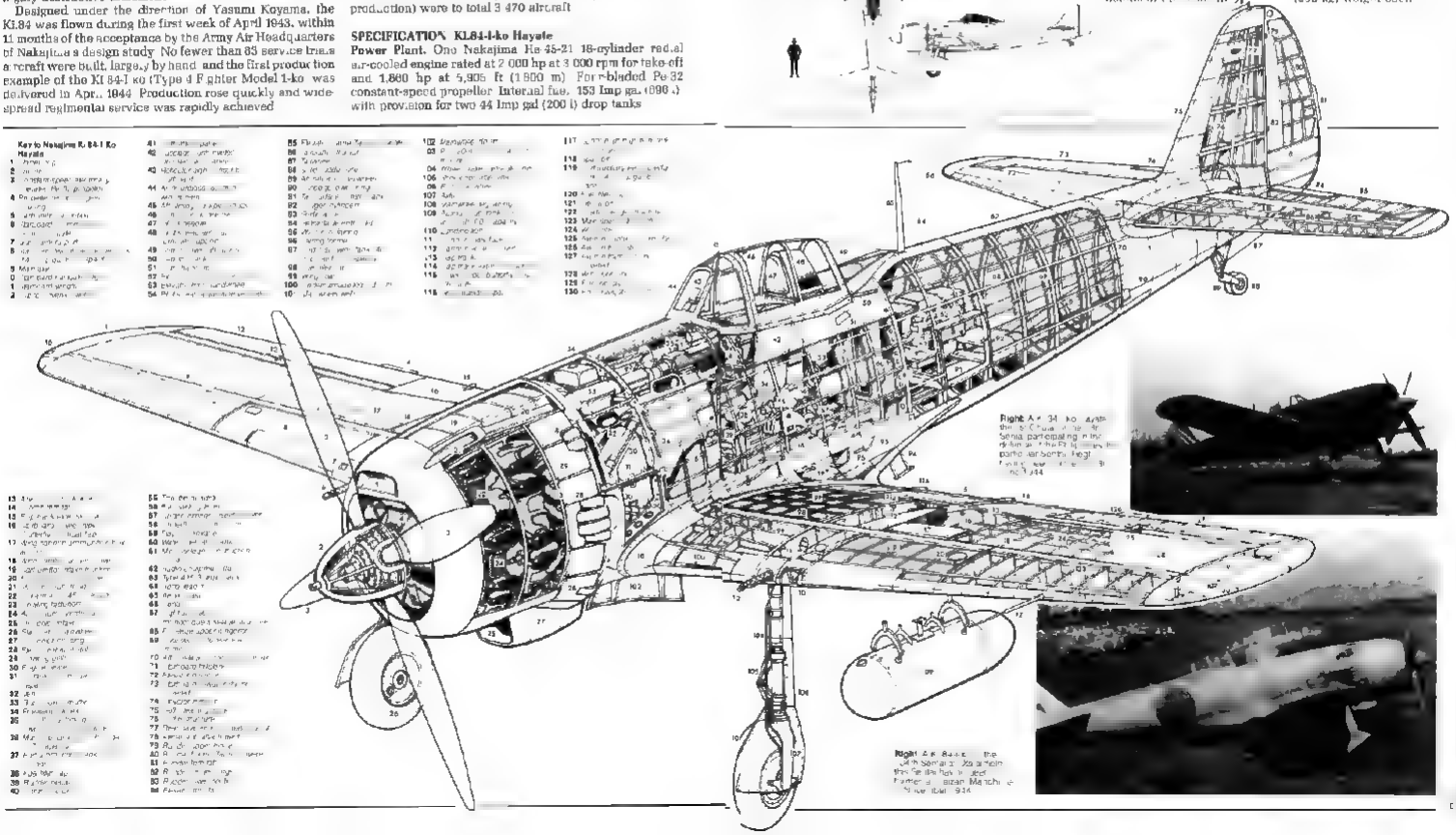
Power Plant. One Nakajima Ha-45-21 18-cylinder radial air-cooled engine rated at 2,000 hp at 3,000 rpm for take-off and 1,860 hp at 5,905 ft (1,800 m). Four-bladed Ha-32 constant-speed propeller. **Internal fuel.** 153 Imp gal (696 l) with provision for two 44 Imp gal (200 l) drop tanks.

Performance. Max speed 325 mph (523 km/h) at sea level, 382 mph (582 km/h) at 9,840 ft (3,000 m), 388 mph (624 km/h) at 21,325 ft (6,500 m), range (max internal fuel) 1,025 mls (1,650 km) at 178 mph (286 km/h) at 11,640 ft (3,550 m), 780 mls (1,255 km) at 254 mph (408 km/h) (with drop tanks), 1,815 mls (2,920 km) at 173 mph (278 km/h), 1,410 mls (2,270 km) at 241 mph (388 km/h). Initial climb, 3,790 ft/min (19.25 m/sec); time to 16,405 ft (5,000 m), 5.42 min; to 26,245 ft (8,000 m), 11.00 min; service ceiling, 30,090 ft (11,000 m).

Weights: Empty equipped, 5,864 lb (2,660 kg); normal loaded, 8,192 lb (3,716 kg); max, 9,195 lb (4,171 kg).

Dimensions. Span 36 ft 2 in (11.02 m); length 32 ft 6½ in (9.92 m); height, 11 ft 1 in (3.38 m); wing area 226.04 sq ft.

Armament. Two 20 mm Ho-5 cannon with 150 rpg and two 13 mm Ho-103 machine guns with 350 rpg. Provision for two bombs of up to 551 lb (250 kg) weight each.



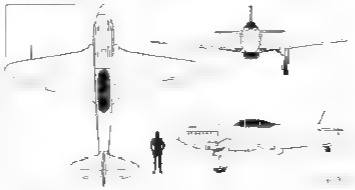
Key to Nakajima Ki.84-I Ko Hayate

Yakovlev Yak-3 (April 1943)

Soviet Union

With the changing requirements of aerial warfare as WWII evolved, the practice of developing versions of existing aircraft optimised to cater for one specific portion of the overall fighter combat spectrum was pursued with increasing vigour by all the principal combatants. A noteworthy example of this practice was provided by Aleksandr Yakovlev's bureau as a result of a 1942 order calling for delivery, in the shortest possible time, of an advanced performance fighter dedicated to the battlefield low altitude air superiority task.

The time factor left no option but to develop the basic Yak-1 for this specialised role, and one of Yakovlev's team leaders K V Sinelshchikov, was given the task of ascertaining the means of endowing this fighter with the attributes called for. The Klimov bureau was asked to boost the low altitude performance of its M-105PF engine—a requirement that was to be fulfilled by raising the revs at considerable expense to the TBO—and Sinelshchikov undertook a thorough weight analysis of the design simultaneously introducing a variety of aerodynamic improvements. The section and basic planform of the Yak-1 wing were retained, but aspect ratio (span and area) was reduced, a shallower cockpit canopy with frameless windscreen was designed, and engine cowling contours were refined by transferring the oil cooler intake to the wing root.



The result, the Yak-3, was flown in April 1943, reaching frontline regiments in quantity early summer 1944. Exceptionally light on the ailerons, light stick pressures producing fast and accurate snap rolls, the Yak-3 proved outstandingly manoeuvrable. It could complete a full 360 deg combat turn in 18·5 seconds, starting at 3 280 ft (1 000 m) and gaining 3,940 ft (1 200 m) in the process. Stalling speed was high, however, and there was a marked tendency to drop a wing on the approach unless speed was kept up.

In the late autumn of 1943, the Yak-3 airframe was mated with the 1 650 hp M-107A engine, production commencing a year later as the Yak-3U, and, three months later with the mixed structure giving place to one of metal throughout with light alloy stressed skinning. Production of this definitive Yak-3U was to continue until early 1946, when 4,848 Yak-3s of all types had been built. The Yak-3U was the fastest of all production piston-engined Yakovlev fighters, its speed ranging from 398 mph (622 km/h) at 1,640 ft (500 m) to 447 mph (720 km/h) at 16,045 ft (5 500 m), but it entered service too late to achieve operational deployment during World War II.

SPECIFICATION Yak-3

Power Plant: One Klimov M-105PF-2 12-cylinder vee liquid-cooled engine rated at 1 244 hp at 2,700 rpm for take-off and 1,300 hp at 2,625 ft (800 m). Three-bladed VISh-105SV constant-speed propeller. Internal fuel capacity, 60·5 Imp gal (275 l).

Performance: Max speed, 367 mph (590 km/h) at sea level, 384 mph (618 km/h) at 3,280 ft (1 000 m), 390 mph (628 km/h) at 6,560 ft (2 000 m), 407 mph (655 km/h) at 10 170 ft (3 100 m); range 416 m.s (670 km) at 332 mph (534 km/h), 560 mls (900 km) at 193 mph (310 km/h); initial climb, 3,800 ft/min (19·3 m/sec); time to 16,405 ft (5 000 m) 4·1 min, service ceiling 35,450 ft (10 800 m).

Weights: Empty equipped, 4,641 lb (2 105 kg); normal loaded, 5,864 lb (2 660 kg).

Dimensions: Span 30 ft, 2¾ in (9,20 m), length, 27 ft 10¾ in (8·49 m), height, 7 ft 11¼ in (2·42 m), wing area, 159·63 sq ft (14,83 m²).

Armament: One 20-mm Shpitalnyy-Vlad'mirov ShVAK cannon with 120 rounds and two 12·7-mm Berezin UB machine guns with 250 rpg.

Left: An early production Yak-3 photographed during an entrance flight testing. The Yak-3 was widely operated above [illegible] and was unsurpassed in manoeuvrability and rendered an ideal low altitude interceptor fighter.

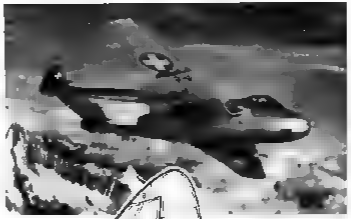
De Havilland Vampire (September 1943)

In view of the comparatively low thrusts afforded by early turbojets the friction losses that were the inevitable consequence of long intake ducts and tailplanes could be ill afforded by designers of first generation jet fighters. As a means of overcoming the problem in a single-engined arrangement R.E. Bishop and his team opted, in designing the Vampire, for a twin-boom configuration, the turbojet being mounted in a short central nacelle drawing air from wing root intakes and exhausting between the tailbooms. While this configuration was not to see general acceptance, it was to characterise all de Havilland jet fighters, being retained successively for the Venom and Sea Vixen.

The Vampire was flown on 28 September 1943, the production F Mk 1 flying 18 months later, on 20 April 1945 and 288 being built. With the 41st aircraft the 2 700 lb (1 225 kg) Goblin 1 turbojet gave place to the 3 100 lb (1 406 kg) Goblin 2, the 51st aircraft introducing cabin pressurization. The F Mk 1 was superseded by the F Mk 3, which, with increased internal fuel and redesigned tail, flew on 4 November 1945, 209 being built plus 80 essentially similar F Mk 30s in Australia.

Unquestionably one of the most aerobatic jet fighters ever to enter service, the Vampire was particularly noteworthy for the outstanding lightness and sensitivity of its controls at speed, remarkable manoeuvrability being demonstrated within the 400-500 mph (645-805 km/h) speed range. Between Mach 0·71 and 0·76, however, the Vampire tended to porpoise with marked wing buffet. At lower speeds, coarse use of the small rudders was necessary to maintain height in steep turns and the Vampire stalled easily in comparatively shallow turns, a wing dropping sharply. The power response of the Goblin was leisurely and rapid throttle movements could result in engine surge or flame out. No relight system was provided and thus a flame out rendered a forced landing inevitable.

Introduced in 1948 as a fighter-bomber, the FB Mk 5 was to prove the most prolific version of the Vampire and was widely exported. In addition to 1,149 built in the UK, plus 302 examples of the tropicalised FB Mk 6—it was licence built in France (67), Italy (80) and India (281) as the FB Mk 52, and in Switzerland (100) as the FB Mk 6.



Above: [illegible] Mk 6 of the Swiss Flight [illegible] built in Switzerland and a further three assembled from spare components.

SPECIFICATION, Vampire FB Mk 5

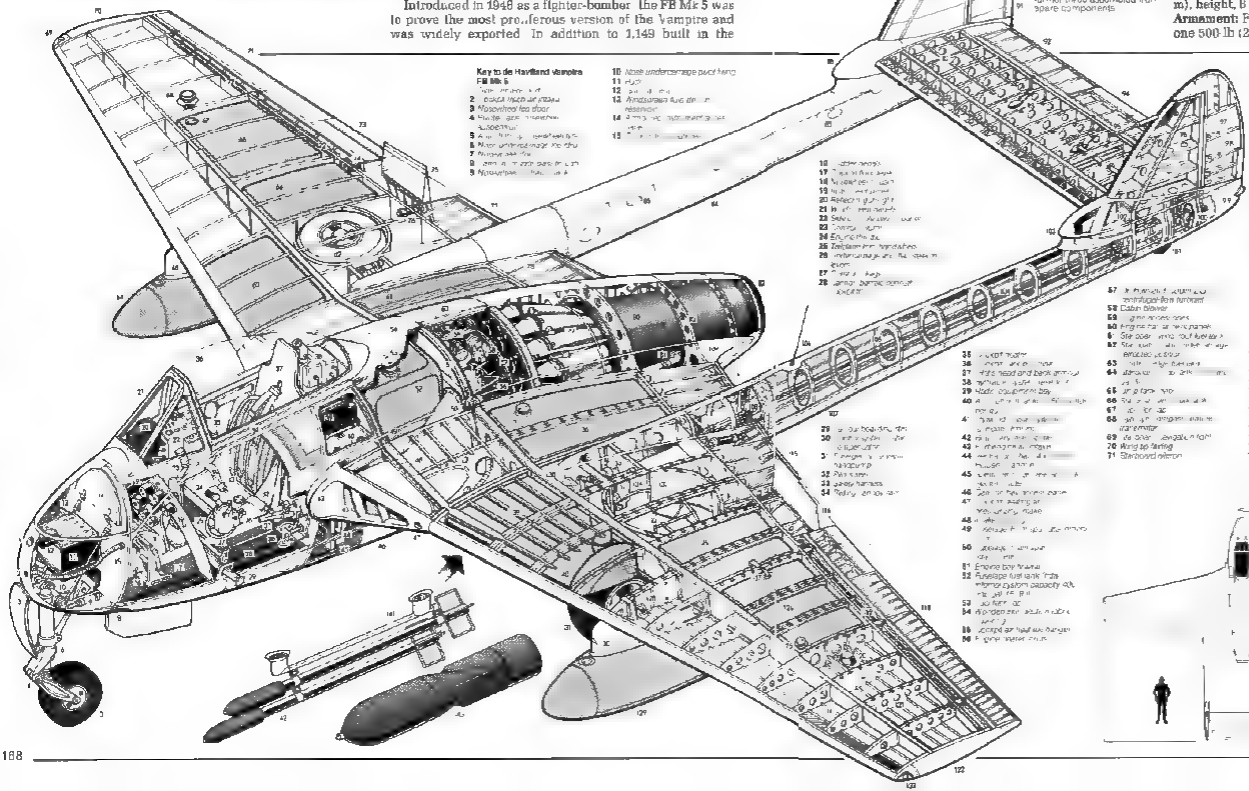
Power Plant: One de Havilland Goblin 2 centrifugal-flow turbojet rated at 3 100 lb (1 406 kg) thrust. Internal fuel capacity, 330 Imp gal (1 500 l), with provision for two 100 Imp gal (455 l) drop tanks.

Performance: Max speed, 531 mph (854 km/h) at sea level, 525 mph (845 km/h) at 17,500 ft (5 335 m), 505 mph (813 km/h) at 30 000 ft (9 145 m); range (with drop tanks), 590 mls (950 km) at 350 mph (563 km/h) at sea level, 1,145 mls (1 843 km) at 30 000 ft (9 145 m); initial climb, 4,050 ft/min (20·5 m/sec); service ceiling, 43,500 ft (13 255 m).

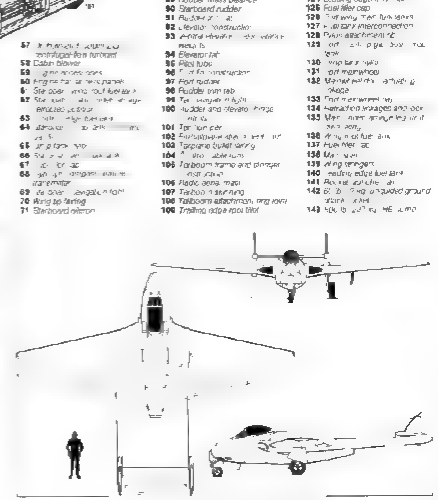
Weights: Empty, 7,253 lb (3 290 kg); normal loaded, 10,520 lb (4 772 kg); max, 12 360 lb (5 608 kg).

Dimensions: Span, 38 ft 0 in (11,58 m); length, 30 ft 9 in (9,37 m); height, 8 ft 2 in (1,88 m); wing area, 262 sq ft (24·34 m²).

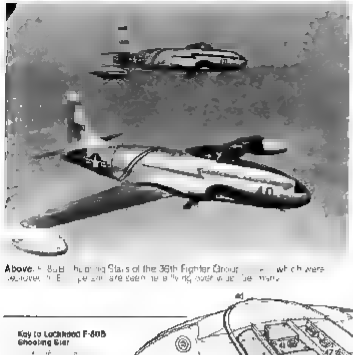
Armament: Four 20-mm Hispano cannon with 125 rpg, plus one 500-lb (226,8-kg) or 1,000-lb (453·6-kg) bombs.



Key to de Havilland Vampire FB Mk 5



Lockheed F-80 Shooting Star (January 1944)



Above: [illegible] Shooting Stars of the 36th Fighter Group [illegible] which were [illegible]

More advanced conceptually and aerodynamically than either of its British contemporaries, the Shooting Star was nevertheless, to suffer the indignity, within five years of service entry of establishing that the legacy of advanced aerodynamic data left by Germany had already rendered first-generation jet fighters patently obsolete. This was to be demonstrated dramatically over Korea late in 1950, when the Shooting Star encountered the MiG-15 in the first jet-versus-jet melees. The Shooting Star was totally outclassed. Too late for WW II, it was already outdated when the Korean conflict commenced a mere half decade later!

The first jet fighter accepted for operational use by the US forces, the Shooting Star was designed by Clarence L. Johnson around the British Halford H-1B turbojet and the XP-80 flew with this power plant on 8 January 1944. Allis-Chalmers' inability to deliver a licence-built version of the H-1B within an acceptable timescale dictated fundamental redesign for the General Electric I-40 (J33-GE-11) and as the XP-80A, with increased overall dimensions and fuel tankage, a further prototype flew on 10 June 1944, 138 days from commencement of redesign.

Exceptionally clean aerodynamically, the P-80 set several design precedents. It featured hydraulically-boosted control surfaces, fuselage-mounted airbrakes and a detachable aft fuselage. Thirteen YP-80As preceded delivery in February 1945 of the first production P-80A, 877 of which were built (including 114 as photo-recce FP-80As) to be followed by 240 P-80Bs with thinner wing section and a water injection-boosted J33-A-21 turbojet. The definitive mode was the J33-A-23-powered P-80C of which 798 were built, during 1946-49, a further 254 A- and B-models being converted to similar standards.

The P-80 was redesignated F-80 in June 1948, and with the appearance of the MiG-15 over Korea was relegated to the fighter-bomber role until April 1953, being withdrawn from first-line USAF squadrons within eight months of the end of the Korean conflict.

SPECIFICATION, P-80A-1 Shooting Star

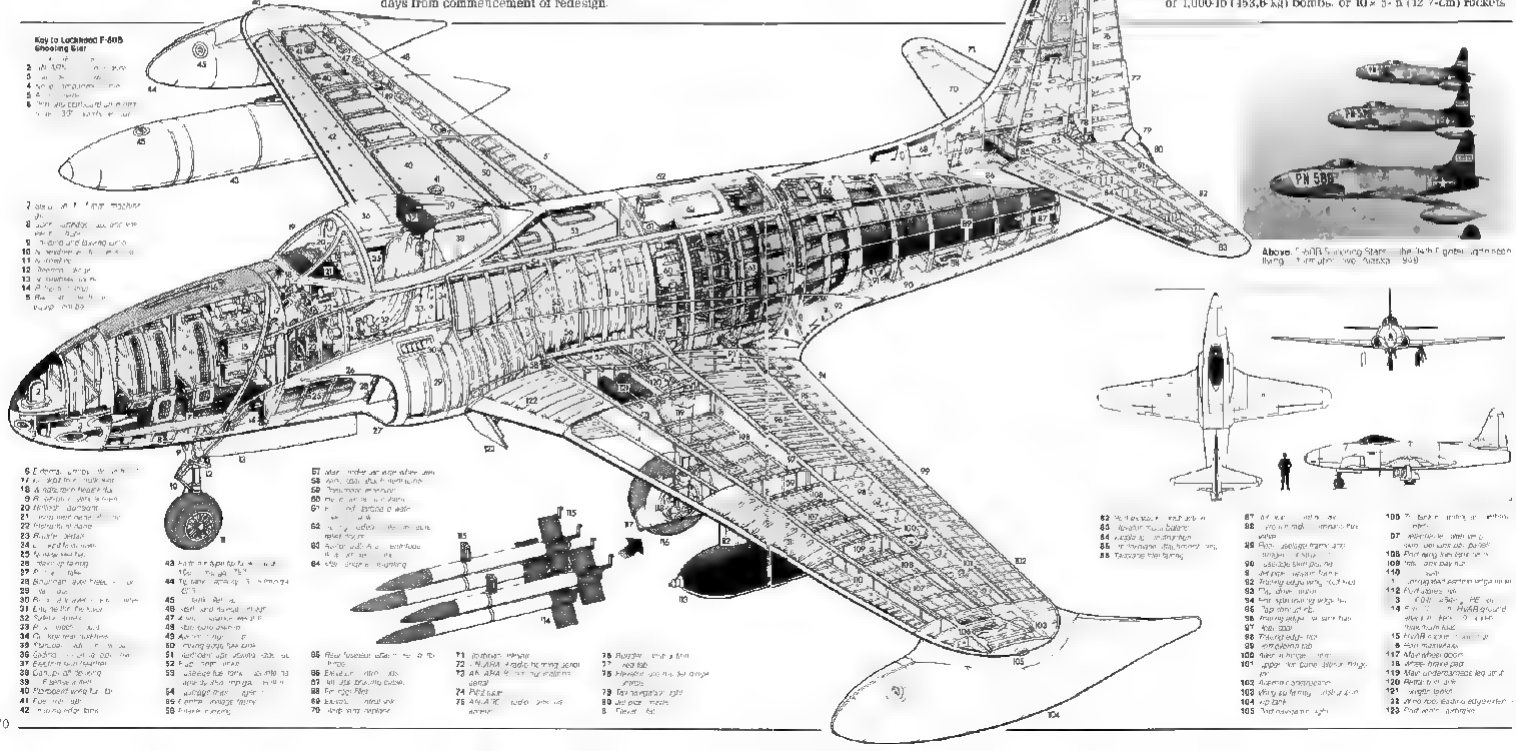
Power Plant: One General Electric/Allison-built J33-A-9 or GE-11 centrifugal-flow turbojet rated at 3,850 lb (1 746 kg) thrust. Internal fuel capacity 354 Imp gal (1 609 l), with provision for two 137 5 Imp gal (625 l) or 191 5 Imp gal (871 l) wingtip drop tanks.

Performance: Max speed, 558 mph (898 km/h) at sea level, 548 mph (882 km/h) at 10,000 ft (3 050 m), 593 mph (858 km/h) at 40,000 ft (6 100 m), range (internal fuel) 780 mls (1 255 km) at 410 mph (660 km/h) at 35 000 ft (10 670 m) (two 137 5 Imp gal (625 l) drop tanks), 1,100 mls (1 770 km) at 407 mph (655 km/h) at 25,000 ft (7 620 m), time to 5,000 ft (1 525 m), 1 2 min, to 10,000 ft (3 050 m), 2·4 min to 20,000 ft (6 100 m), 5·5 min, service ceiling, 45,000 ft (13 7.5 m).

Weights: Empty, 7,920 lb (3 593 kg) normal loaded, 11,700 lb (5 307 kg) max, 14,000 lb (6 350 kg).

Dimensions: Span 38 ft 10½ in (11.85 m), length 34 ft 5 in (10 51 m), height 11 ft 4 in (3 45 m), wing area, 237 8 sq ft.

Armament: Six 0 50-in (12 mm) Colt Browning M-2 machine guns with 300 rpg, provision for 2 × 500-lb (226 8-kg) or 1,000-lb (453,6-kg) bombs, or 10 × 5-in (12 7-cm) rockets.



Above: [illegible] Shooting Stars [illegible]

Grumman F8F Bearcat (August 1944)

Above A [illegible] of the 50th [illegible] to equip with this sight [illegible] Operating from USS Bataan this F8F was flown by the Air Group Commander

Representative of the final generation of piston-engined shipboard fighters, the F8F had its genesis in the earliest phases of the Pacific conflict and the impact of the minimum weight concept Japanese fighters encountered by the US Navy. The F8F was conceived as a pure air superiority fighter, consciously sacrificing range to speed and agility. The principal design aims were climb and roll rates at least twice those of the F6F (see pages 158-159) with 45-50 mph (70-80 km/h) more speed.

The first prototype (XF8F-1) was flown on 31 August 1944, with the first of 23 trials aircraft following early in February 1945. Somewhat overpowered, the F8F offered fantastic acceleration, and its beautiful harmony of controls was aided by its spring tab ailerons. Stability was rather poor, somewhat in the manner of the Spitfire, making for an outstandingly aerobatic aeroplane, but the F8F gave little warning of the onset of a stall, its nose dropping hard and twisting violently left.

Awaiting combat deployment when Pacific hostilities ceased, the Bearcat remained in production until May 1949. 19 US Navy squadrons flying the type. Of 872 F8F-1s, the last 126 were carrier-qualified. The 1Bs. The 2 II more powerful F8F-2 (365 built) replaced the -1 on the line in late 1947.

SPECIFICATION: F8F-1 Bearcat

Power Plant One Pratt and Whitney R-2800-34W Double Wasp 18-cylinder two-row radial air-cooled engine rated at 2,100 hp at 2,800 rpm for take-off and 2,450 hp at 9,600 ft (2,925 m). Four-bladed Aeroproducts constant-speed propeller. **Internal fuel capacity** 154 Imp gal (700 l), with provision for one 125 Imp gal (568 l) centreline and two 166.5 Imp gal (757 l) wing drop tanks.

Performance With centreline tank: Max speed, 423 mph (680 km/h) at 15,000 ft (4,570 m); 428 mph (689 km/h) at 18,800 ft (5,730 m); range (max external fuel), 1,416 mls (2,279 km); initial climb, 5,610 ft/min (28.50 m/sec); time to 20,000 ft (6,095 m), 4.9 min.

Weights Empty, 7,328 lb (3,322 kg); normal loaded, 9,872 lb (4,397 kg); max, 12,740 lb (5,779 kg).

Dimensions Span 35 ft 8 in (10.92 m); length, 27 ft 8 in (8.43 m); height 13 ft 8 in (4.16 m); wing area, 244 sq ft (22.67 m²).

Armament: Four 0.50-in (12.7 mm) Colt-Browning machine guns with 300 rounds of ammunition for each gun, and provision also for four 5-in (12.7 cm) rockets or two 1,000-lb (453.6-kg) bombs.

Above The F8F-2 introduced a dorsal fin that to modify a marginal longitudinal stability problem in the Bearcat's F6F-derived airframe. The engine rated at 2,450 hp for take-off. The last F8F was rolled out in May 1949.

Key to Grumman F8F-1 Bearcat

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Hawker Sea Fury (September 1944)

A contemporary of the Bearcat (see pages 172-173), with much the same installed power but rather larger and 20 per cent heavier, the Sea Fury was similarly representative of the zenith of long years of propeller-driven fighter development overtaken by technological advances while still in infancy. As with the Bearcat, the Sea Fury's arrival aboard the carriers signified the beginning of the end of the piston-engined shipboard fighter era. It was to write the finale to its genre in the skies above Korea during 1950-1952.

Initially evolved in both shipboard and land-based versions, the first prototype flown on 1 September 1944 represented the land-based variant, with the fundamentally similar "semi-navalised" (in that it lacked wing folding facilities) prototype following on 21 February 1945 and a "fully-navalised" prototype flying eight months later, on 12 October. The initial production version, the Sea Fury F Mk 10, entered service from the spring of 1947. Only 50 F Mk 10s were built before replacement by the more versatile FB Mk 11, 615 of which had been built when production ended in November 1950. The FB Mk 11 constituted the principal Royal Navy single-seat fighter equipment until the advent of its lineal successor, the Sea Hawk (see pages 180-181), in late 1953.

Compact, sturdy and tractable, the Sea Fury was a true pilot's aeroplane. Marginally stable about all three axes, it had light and effective controls, and while a comparison with the Bearcat assuredly gave an edge in climb and manoeuvrability to the US Navy fighter, the Sea Fury was the better weapons platform and the superior aircraft under instrument flight conditions.

SPECIFICATION: Sea Fury FB Mk 11

Power Plant: One Bristol Centaurus 18 18-cylinder two-row radial air-cooled engine rated at 2 480 hp at 2,700 rpm for take-off and 2 550 hp at 4 000 ft (1,220 m). Five-bladed Rotol constant speed propeller. Internal fuel capacity, 200 imp gal (909 l), with provision for two 45 imp gal (204 l) or 90 imp gal (409 l) drop tanks.

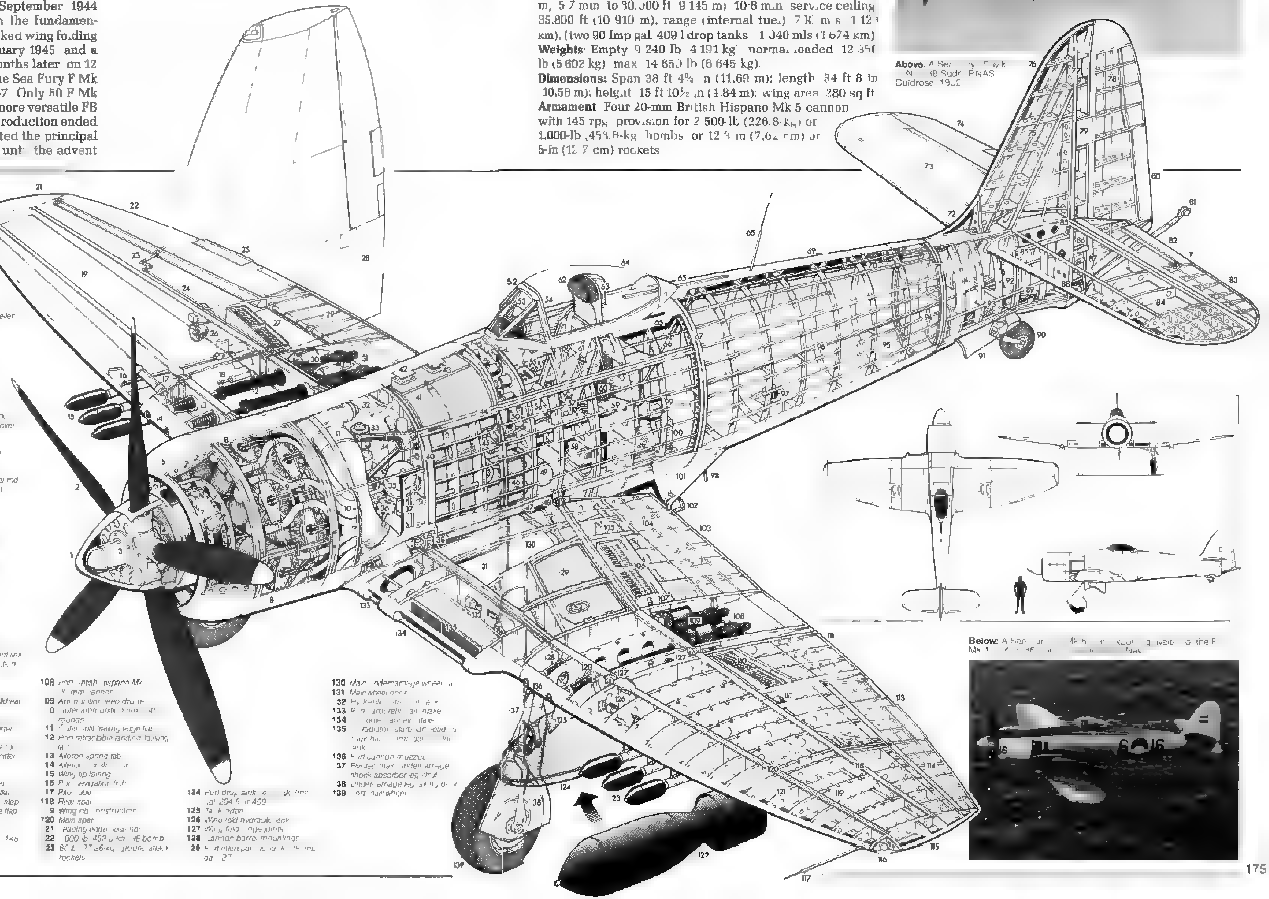
Performance: Max speed, 460 mph (740 km/h) at 18 000 ft (5 485 m); 435 mph (668 km/h) at 30,000 ft (9 145 m); initial climb, 4,320 ft/min (21.94 m/sec); time to 20,000 ft (6 095 m), 5.7 min; to 30,000 ft (9 145 m), 10.8 min; service ceiling, 35,800 ft (10 910 m); range (internal fuel), 730 mls (1 174 km); (two 90 imp gal 409 l drop tanks), 1 340 mls (1 674 km).

Weights: Empty, 9 240 lb (4 191 kg); normal loaded, 12 350 lb (5 602 kg); max, 14 850 lb (6 645 kg).

Dimensions: Span, 38 ft 4½ in (11.68 m); length, 34 ft 8 in (10.56 m); height, 15 ft 10½ in (4.84 m); wing area, 280 sq ft.

Armament: Four 20-mm British Hispano Mk 5 cannon with 145 rpg; provision for 2 500-lb (226.8-kg) or 1,000-lb (453.6-kg) bombs, or 12 × 60-lb (27.2-kg) or 8-in (20.3-cm) rockets.

Above: A Fleet Air Arm Mk 11 of 18 Sqdn, FRAS Culdrose, 1952.



Key to Hawker Sea Fury FB Mk 11

1 Spinner
2 Rotol five-blade constant speed propeller, 12 ft 9 in (3.88 m) diameter
3 Propeller hub pitch change mechanism
4 Spinner backplate
5 Engine mounting ring
6 Cooling air intake
7 Propeller reduction gearbox
8 Detachable engine mountings
9 Bristol Centaurus Mk 18 18-cylinder two-row radial air-cooled engine
10 Exhaust stubs
11 Engine mounting bulkhead
12 Six Hispano British Mark 5 20-mm cannon
13 Rear gun blast tube
14 Spring-in access panel
15 Port 45-imp gal (204-l) fuselage pannier
16 Port length of fuselage fuel tank
17 Wing fairing hinge attachment
18 Wing fold operating rod fairing
19 Starboard outer wing panel
20 Wing skin tapering to tip
21 Wing tip fairing
22 Wing skin stiffeners
23 Aileron hinge centers
24 Rear spar, inner wing
25 Aileron spring tab
26 Wing skin stiffeners, inner panel
27 Skin joint, inner panel to outer panel starboard
28 Rear spar, wing, inner to outer
29 Outer spar fairing outboard flap
30 Aileron, wing, inner to outer panels
31 Spar to inner panel
32 Outer panel fairing to inner panel
33 Wing root fairing, port side
34 Undercarriage door actuator
35 Wing root fairing, starboard side
36 Accessory drive gearbox
37 Port inner fuel tank, 90 imp gal
38 Wing front spar assembly, port
39 Undercarriage retraction jack, port side
40 Fuselage double frame
41 Main fuselage fuel tank, 90 imp gal
42 Fuel tank vent
43 Fuel gauge
44 Fuselage longeron
45 Rudder pedal
46 Aileron, fuselage two-frame, 30 imp gal
47 Fuselage bottom longeron
48 Rear wing, port side forward joint
49 Tail spar, rear
50 Control column
51 Instrument panel
52 Rear, front armor plate
53 Mk 4 reflector sight
54 Windscreen framing
55 Pilot's starboard side console
56 Rear spar
57 Engine mounting bearer bulkhead
58 Port engine bearer
59 Port side console
60 Seat, adjustable pan
61 Safety harness
62 Headrest
63 Arm rest, hydraulic
64 Seat, adjustable, pan
65 Seat pan
66 Aileron control rod
67 Rear fuselage, port side
68 Wing spar
69 Fuselage, port side
70 Elevator push-pull control rod
71 Aileron push-pull control rod
72 Fin, port side
73 Starboard elevator
74 Elevator, starboard
75 Spar, construction
76 Curved fin, port side
77 Tailplane
78 Rudder, metal skin
79 Metal skin, fin
80 Rudder, tip
81 Rear fuselage, port side
82 Elevator trim tab
83 Port tailplane
84 Aileron, metal construction
85 Aileron, port side
86 Rudder, hinge centers
87 Fin, starboard side
88 Arresting hook, stowed position
89 Starboard hydraulic reservoir, 5 gal
90 Pitot tube
91 Stowed drogue
92 Rear fuselage, port side
93 Stowed bay
94 Stowed bay, port side
95 Fuselage, port side, monocoque construction
96 Rudder, port side
97 Rudder, port side, metal construction
98 Vertical fin
99 Fuselage
100 Rear fuselage, starboard side
101 Trailing edge wing root fairing
102 Rear, port side, wing root
103 Rear spar, port side
104 Rear, starboard structure
105 Spar, starboard side
106 Inboard ammunition box, 150 rounds
107 Aft arm, port side hook
108 Arm, port side, hydraulic
109 Port side, hydraulic
110 Port side, hydraulic
111 Port side, hydraulic
112 Port side, hydraulic
113 Port side, hydraulic
114 Port side, hydraulic
115 Port side, hydraulic
116 Port side, hydraulic
117 Port side, hydraulic
118 Port side, hydraulic
119 Wing root, port side
120 Main spar
121 Port side, hydraulic
122 Port side, hydraulic
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Below: A Fleet Air Arm Mk 11 of 18 Sqdn, FRAS Culdrose, 1952.

McDonnell FH-1 Phantom (January 1945)

Use of the turbo jet as an aircraft prime mover was to arouse US Navy interest from the beginning of the 'forties but application of pure jet aircraft to shipboard operations posed numerous problems. Turbojet-powered aircraft consumed prodigious quantities of fuel, they called for the use of a nosewheel undercarriage with which no flight deck experience existed; their take-off run was excessive by carrier standards, rendering catapult launching a necessity, and their high landing speed demanded improved arresting techniques.

Despite these problems on 7 January 1943 development began of a single-seat shipboard fighter, which, to be powered solely by turbojets, was to emerge two years later as the Phantom. The Phantom was to make two claims to fame in fighter annals, one substantive and the other vicarious. It was the first pure jet fighter designed from the outset for the shipboard operation and it was to be the sire of the Phantom II (see pages 216-217), the most significant and efficacious fighter of the 'sixties.

Comparatively conservative and fundamentally simple in design, the Phantom was created by a team led by Kendall Perkins, and the first of two prototypes was flown as the XFD-1 on 26 January 1945 (with only one turbojet installed as delivery of the second was still awaited. Production was initiated 40 days later, on 7 March, with deliveries of 60 aircraft commencing as FH-1s in January 1947. The Phantom was operated from a carrier deck for the first time on 21 July 1946, emulating the feat of a Hooked Vampire seven-and-a-half months earlier which had proved the feasibility of carrier-based jet operations.

Decidedly underpowered, the Phantom was stable under all conditions, but stick forces tended to be one unacceptably light with all movement of the CG, as when ammunition was expended. Power variations resulted in only small trim changes, and extension of the undercarriage and flaps produced only a mild nose heaviness. At higher speeds, however, harsh buffeting, a strong nose-up tendency, and rolling instability strictly limited performance.

The sole US Navy squadron to equip with the Phantom became carrier qualified on 5 May 1948. Two US Marine Corps squadrons also flew the Phantom, which was finally withdrawn from service mid-1950.

SPECIFICATION: FH-1 Phantom

Power Plant: Two Westinghouse J30-WE-20 axial-flow turbojets each rated at 1,560 lb (708 kg) thrust. Internal fuel capacity 312 Imp gal (1,418 l), with provision made for one 155 Imp gal (704 l) or one 245.6 Imp gal (1,117 l) centreline drop tank.

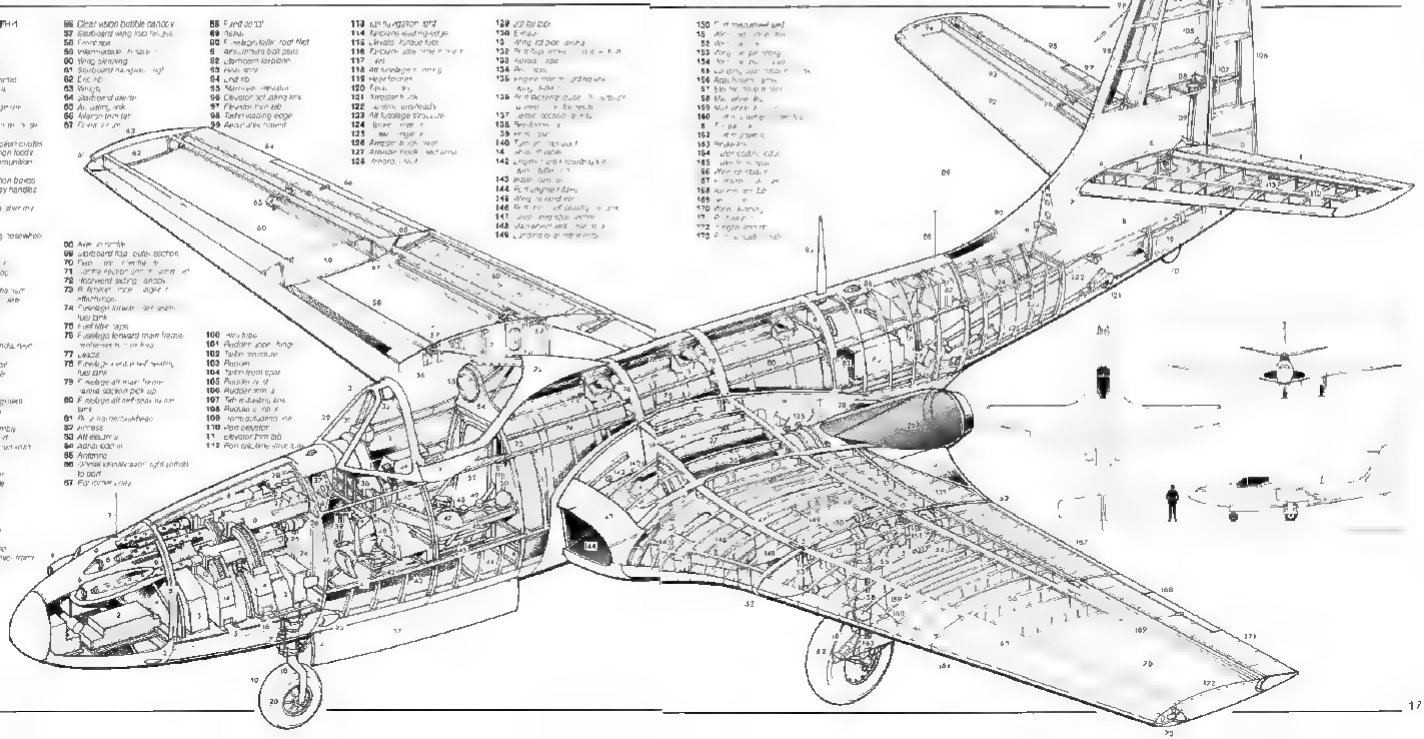
Performance: Max speed, 472 mph (760 km/h) at sea level, 465 mph (780 km/h) at 15,000 ft (4,570 m). Initial climb 4,800 ft/min (24.38 m/sec); time to 30,000 ft (9,145 m) 11.0 min; service ceiling, 34,500 ft (10,515 m); range with 156 Imp gal, 718 l drop tank, 771 mls (1,241 km) at 312 mph (502 km/h) at 20,000 ft (6,095 m); ferry range (with 245.6 Imp gal, 1,117 l drop tank), 910 mls (1,464 km) at 307 mph (494 km/h).

Weights: Empty 6,899 lb (3,129 kg), normal loaded 9,974 lb (4,524 kg), max 12,500 lb (5,670 kg).

Dimensions: Span, 40 ft 6 in (12.42 m); length, 38 ft 9 in (11.81 m); height, 14 ft 2 in (4.32 m); wing area, 274 sq ft (25.45 m²).

Armament: Four 0.50-in (12.7 mm) Colt-Browning machine guns with 325 rpg.

Above: The Phantom was US Marine Corps squadron VMF-122's operational equipment. Mt AS, Jacksonville, Point, North Carolina, the beginning was made by FH-1s.



Key to McDonnell FH-1 Phantom

1 Nose cone
2 Forward radio bay
3 Air conditioning duct
4 Suction valve
5 Fuselage forward frame
6 Gun muzzle ports
7 Forward spar
8 Gun ... upper longeron
9 Gun barrels
10 ...
11 Starboard gunsight equipment
12 Port guns ammunition feeder
13 Starboard guns ammunition feeder
14 Port guns ammunition boxes
15 Ammunition box tray handles
16 Suction valve
17 Nosewheel steering actuating rod
18 Nosewheel fork
19 Recessed retracting nosewheel
20 Hub
21 Torque links
22 Nosewheel axle fork
23 Auxiliary rubber shock
24 Brake line
25 Gun hanging mounting
26 Air duct
27 Gun breech cap
28 Gun hinge mount
29 Windscreen frame
30 VHF 23 antenna
31 Windscreen glass windshield
32 Sensitive tube
33 Rocket sight equipment
34 Rear spar
35 Cockpit floor
36 Instrument panel
37 Starboard panel equipment
38 Control stick
39 Control linkage
40 Rudder pedal assembly
41 Rudder foot support
42 Undercarriage control valve
43 Air bottle
44 Bulkhead
45 Tube ...
46 Rear control console
47 Trim ...
48 Trim tab actuator
49 Tailplane mount
50 Tailplane frame
51 Seat support frame
52 Seat rail
53 Canopy stop release
54 Lock of aircraft turning, frame support
55 Padded headrest
56 Clear vision bubble canopy
57 Starboard wing root fairing
58 Control rod
59 Intermediate frame
60 Wing skinning
61 Starboard navigation light
62 Ailerons
63 Winglet
64 Starboard aileron
65 Aileron spar
66 Aileron hinge
67 Flap ...
68 Flap
69 Fuselage fairing root flap
70 Fuselage ... root flap
71 Starboard bolt plate
72 Wing skinning
73 Starboard navigation light
74 Fuselage lower ... tail cone
75 Port flap
76 Fuselage forward main frame
77 Keelson
78 Fuselage ... tail section
79 Fuselage aft main frame
80 Fuselage aft ... tail section
81 Fuselage ... tail section
82 Jetties
83 Aft ... frame
84 Aerial ...
85 Antenna
86 Starboard navigation light (other to port)
87 Fin ...
88 Fin ...
89 Fin ...
90 Aileron ...
91 Starboard flap outer section
92 Flap ...
93 Port ... hinge
94 Starboard ... aileron
95 Starboard ... aileron
96 Port ... aileron
97 Port ... aileron
98 Port ... aileron
99 Port ... aileron
100 Aft tube
101 Rudder upper hinge
102 Tailplane ...
103 Rudder
104 Tailplane ...
105 Rudder ...
106 Rudder ...
107 Tailplane ...
108 Rudder ...
109 Port ... aileron
110 Port aileron
111 Elevator trim tab
112 Port ... aileron
113 Lift ...
114 Retractable ... jet
115 Elevator ... root
116 Port ... tail ...
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118 Air ...
119 Rear ...
120 Port ...
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123 Aft fuselage ...
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Republic F-84 Thunderjet (February 1946)

The first turbojet-powered fighter conceived specifically for the recall of action demanded for the penetration mission, the Thunderjet also represented the culmination of first-generation US single-seat land-based jet fighter evolution. Designed under the aegis of Alexander Kartveli it was distinctive among combat aircraft at the time of its debut in utilising the straight-through airflow concept, which, while penalising internal capacity, simplified induction and exhaust, and was conducive to low internal pressure losses. A simple pilot-type intake combined maximum flow efficiency with the highest possible critical Mach number, minimum fuselage cross section combining with a comparatively high fineness ratio to result in exceptionally low drag. The wing, mounted in low-mid position to minimise interference drag, employed a comparatively thick (12 per cent) constant-section aerofoil in order to accommodate the main undercarriage members and the bulk of the fuel.

The first of three (XP-84) prototypes flew on 28 February 1946, the initial production model, the F-84B flying in June 1947, introducing an ejection seat and a 4,000 lb (1,814 kg) J35-A-15C turbojet. Two hundred and twenty-six F-84Bs were followed by 191 F-84Cs with minor changes and 154 F-84Ds with thicker skin gauges and the 5,000 lb (2,268 kg) J35-A-17D. With the F-84E the Thunderjet emulated its lineal predecessor, the P-47, in finding its true forte as a fighter-bomber, a role in which it excelled. Offering exceptional load-carrying ability, it provided a very stable weapons platform and had good instrument flying characteristics, and the sturdiness to withstand rough airfield conditions and battle damage.

The Thunderjet was exceptionally demanding on runway length and lacked the agility for effectiveness in fighter versus fighter combat. Without external stores it accelerated rapidly owing to its low drag characteristics, quickly attaining its Mach 0·82 limitation when, below 15,000 ft (4,570 m), it produced a sudden and uncontrollable pitch-up and at higher altitudes, extreme buffeting.

Following 843 F-84Es under the impetus of the Korean conflict, 3,025 of the definitive F-84G model were built, 1,936 of these being supplied with MAP funding to foreign air forces, production ending in July 1953.

SPECIFICATION, F-84G Thunderjet

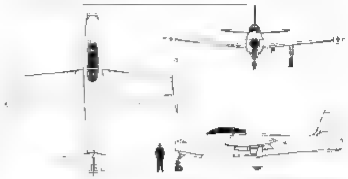
Power Plant: One Allison J35-A-29 axial-flow turbojet rated at 5,600 lb (2,540 kg) thrust. Internal fuel capacity, 376 Imp gal (1,709 l), with provision for two wingtip and two underwing 191·5 Imp gal (870 l) drop tanks.

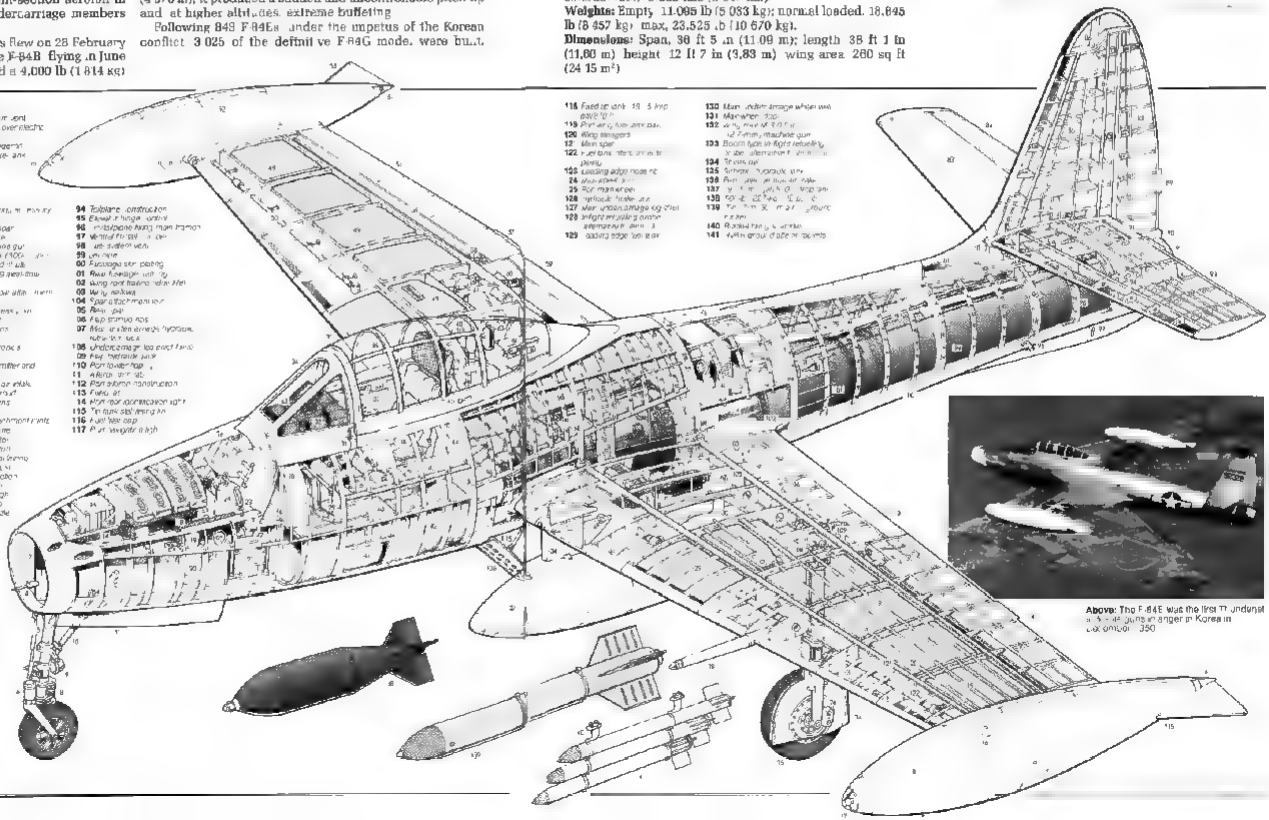
Performance: Max speed, 622 mph (1,000 km/h) at sea level, 575 mph (925 km/h) at 20,000 ft (6,095 m), 549 mph (869 km/h) at 36,000 ft (10,970 m); continuous cruise, 483 mph (777 km/h) at 35,000 ft (10,670 m); time to 35,000 ft (10,670 m), 7·9 min, (with external tanks), 9·4 min; service ceiling, 40,500 ft (12,345 m); range (internal fuel), 670 mls (1,078 km) (with wingtip tanks, 1,330 mls (2,140 km) (with max external fuel), 2,000 mls (3,217 km).

Weights: Empty, 11,095 lb (5,033 kg); normal loaded, 18,845 lb (8,457 kg); max, 23,525 lb (10,670 kg).

Dimensions: Span, 36 ft 5 in (11,09 m); length, 38 ft 1 in (11,60 m); height, 12 ft 7 in (3,83 m); wing area, 260 sq ft (24·15 m²).

Armament: Six 0·50-in (12,7 mm) Colt Browning M-3 machine guns with 300 rpg, with provision for up to 4,000 lb (1,814 kg) of external ordnance.





Key to Republic F-84G Thunderjet

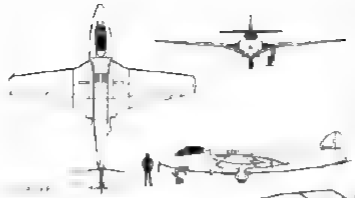
1 Engine air intake
2 Gun firing outlet nozzle
3 Machine gun muzzles
4 Hot tube
5 Main undercarriage leg strut
6 Steering unit
7 Nosewheel
8 Shock absorber
9 Towing arm
10 Nosewheel inner hub cap
11 Nosewheel tyre
12 Nosewheel mudguard
13 Nosewheel hydraulic retraction jack
14 Up-firing gun barrel
15 Gyro gunsight unit
16 Ballast weights
17 Ammunition tanks (300 rounds per gun)
18 M-3 .50-in machine guns
19 Gun barrel support bracket
20 Nosewheel hydraulic retraction jacks
21 Radio
22 Service hatch access panel
23 Rudder hydraulic actuator
24 Rudder
25 Hydraulic system reservoir tank
26 Rudder pedals
27 Armoured bulkhead
28 Cockpit floor level
29 Rudder pedals
30 Instrument panel
31 Windscreen
32 Instrument panel shroud
33 Gunsight mounting bracket
34 Bullet proof windscreen
35 Cockpit canopy hinge
36 Canopy handle
37 Starboard side console
38 Pilot's ejection seat
39 Engine throttle control
40 Cockpit floor level
41 Undercarriage hydraulic lines
42 Brake hydraulic
43 Port side console panel
44 Cockpit rear pressure bulkhead
45 Canopy jettisoning
46 Fuselage nose hoop
47 Pilot's back and head armour
48 Cockpit air intake
49 Aluminium alloy fuselage skin
50 Port side hydraulic system reservoir
51 Port side hydraulic system
52 Cockpit floor level
53 Starboard navigation light
54 Fuselage nose hoop
55 Starboard aileron
56 Aileron hydraulic jack
57 Aileron control linkage
58 Port navigation light
59 Starboard flaps
60 Hydraulic flap jack
61 Tailplane main attachment hinge
62 Drop tank
63 Underwing pylon
64 Strengthened over electric motor and fan
65 Fuselage top longeron
66 Main fuselage skin
67 Brake control linkage
68 Fuselage main spar attachment frame
69 Wing root attachment pin
70 Aluminium head shield
71 Allison J35-A-29 axial-flow turbojet
72 Fuselage rear spar attachment frame
73 Rear fuselage frame, engine removal
74 Engine frame
75 Cooling air duct
76 Radio and electronics equipment bay
77 VHF radio transmitter and receiver
78 Jet pipe cooling air intake
79 Jet pipe heat shroud
80 Control cable runs
81 Tailplane
82 Main tailplane attachment hinge
83 Starboard tailplane
84 Starboard elevator
85 Tailplane
86 Main VHF aerial
87 Rudder hinge
88 Rudder construction
89 Rudder
90 Tail navigation light
91 Elevator trim tab
92 Jet exhaust nozzle
93 Port elevator
94 Tailplane construction
95 Elevator hinge
96 Fuselage main frame
97 Vertical fin
98 Jet pipe
99 Jet nozzle
100 Fuselage skin plating
101 Rear fuselage
102 Wing root fairing
103 Wing airbrake
104 Port airbrake
105 Rear spar
106 Fuel transfer pipe
107 Rear undercarriage hydraulic retraction jack
108 Undercarriage top shock frame
109 Rear fuselage
110 Port tailplane
111 Aileron
112 Rear spar construction
113 Fuel
114 Port navigation light
115 Tip tank attachment
116 Fuel filler cap
117 Port navigation light
118 Fuselage tank 19·5 Imp gal (88 l)
119 Port wing fuel jettisoning
120 Wing stringers
121 Main spar
122 Vertical stiffeners in panels
123 Leading edge nose ribs
124 Wing root
125 Leading edge nose ribs
126 Wing stringers
127 Main undercarriage leg strut
128 Wing root
129 Wing root
130 Main undercarriage wheel well
131 Main wheel tyre
132 Wing root
133 Boom type six-flight refuelling probe
134 Wing root
135 Wing root
136 Port main wheel
137 Port main wheel
138 Port main wheel
139 Port main wheel
140 Rear wing root
141 Main group of gate valves

Above: The F-84E was the first Thunderjet to see action in anger in Korea in late 1950.

Hawker Sea Hawk (September 1947)

Arguably the pre-eminent example of post-WWII combat aircraft pulchritude, the supremely graceful Sea Hawk shipboard fighter was noteworthy for its ingenious arrangement of bifurcated intakes and exhaust orifices. Aesthetically an outstandingly elegant aircraft and aerodynamically extraordinarily clean, the Sea Hawk laid claim to originality not in its wing root leading-edge air intakes but in their mating with similarly bifurcated exhaust pipes via a constant thickness root chord. This arrangement left the fuselage virtually free of ducting and catered for large-capacity fuel tanks fore and aft of the turbojet and, therefore, symmetrical about the CG.

Conceived as the P.1040 land-based interceptor and flown on 2 September 1947, the design was readily adaptable for shipboard use and a "navalised" prototype flew almost exactly a year later, on 3 September 1948. The production Sea Hawk F Mk 1 (95 built) flew on 14 November 1951, aileron oscillation which caused a loss of lateral control being corrected by the introduction of power actuation on the F Mk 2 (40 built). A strengthened wing for external loads produced the FB Mk 3 (116 built), this being succeeded by the close air support FGA Mk 4 (97 built). The definitive production FGA Mk 6 replaced the 5 000 lb (2 268 kg) thrust Nene 101 with the 103, 86 being built for the Royal Navy, with deliveries completed early 1956, followed by 22 similar FGA Mk 50s for the Netherlands and 68 (Mks 100 and 101) for Federal Germany, production terminating in 1961 with a batch of 14 FGA Mk 6s for the Ind an Navy.



SPECIFICATION Sea Hawk FGA Mk 6

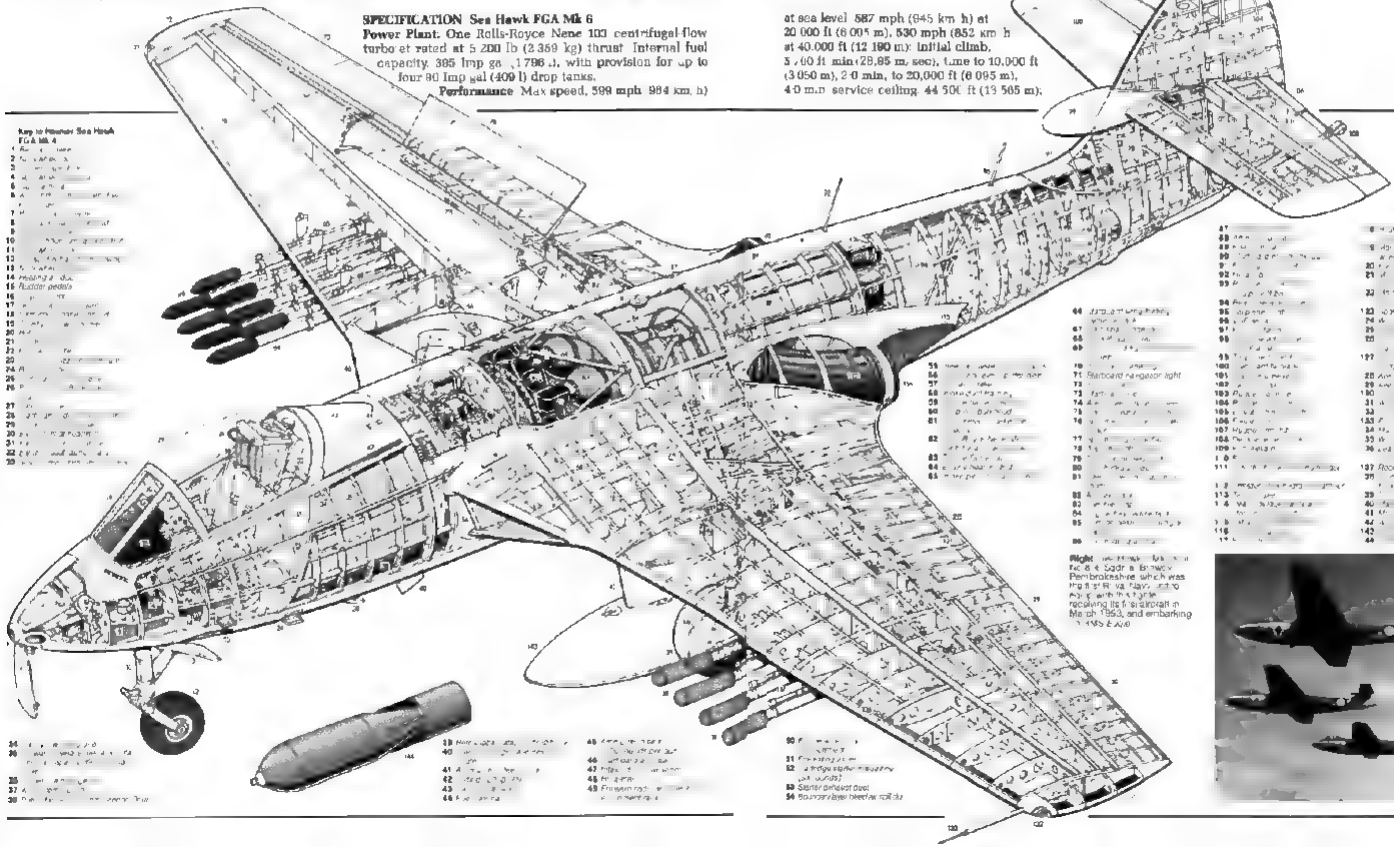
Power Plant: One Rolls-Royce Nene 103 centrifugal-flow turbojet rated at 5 200 lb (2 359 kg) thrust. Internal fuel capacity, 385 Imp gal (1 796 l), with provision for up to four 90 Imp gal (409 l) drop tanks.

Performance: Max speed, 599 mph (964 km/h) at sea level, 587 mph (945 km/h) at 20 000 ft (6 095 m), 530 mph (852 km/h) at 40 000 ft (12 190 m); initial climb, 5 760 ft/min (29,85 m/sec), time to 10,000 ft (3 050 m), 2·0 min, to 20,000 ft (6 095 m), 4·0 min; service ceiling, 44 500 ft (13 565 m); range (internal fuel), 480 mls (772 km) (with two drop tanks), 790 mls (1 271 km).

Weights: Empty, 9,278 lb (4 208 kg); normal loaded, 13 543 lb (6 143 kg); max, 16,153 lb (7 327 kg).

Dimensions: Span, 39 ft 0 in (11,89 m); length, 39 ft 8 in (12,09 m); height, 8 ft 8 in (2,64 m); wing area, 278 sq ft (25,83 m²).

Armament: Four 20-mm British Hispano Mk 5 cannon with 200 rpg, with provision for up to four 500-lb (226 8-kg) bombs or up to 20 3 in (7 62-cm) or 5-in (12,7-cm) rocket projectiles.



Right: [illegible] Sea Hawks of 806 Squadron, Fleet Air Arm, Pembrokeshire, which was [illegible] with the single receiving its first aircraft in May 1953, and embarking [illegible] HMS Eagle

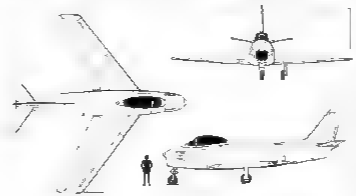
North American F-86 Sabre (October 1947)

An outstanding technological milestone in fighter development was reached with the adoption of wing sweepback. While the Me 262 (see pages 154-155) claimed the distinction of having been the first jet fighter featuring swept wings to attain service, it had utilised sweepback to compensate for a forward CG shift rather than as a means of delaying the onset of compressibility. The F-86 Sabre, on the other hand, was conceived with full knowledge of the aerodynamic advantages to be gained from sweeping wing surfaces. It could thus be claimed to have inaugurated a second generation in jet fighter development, albeit an honour gained by a mere 13-week lead over the Soviet MiG-15 (see pages 184-185).

Designed by a team led by Raymond H. Rice, the Sabre flew as a prototype (XP-86) on 1 October 1947, the first production model (F-86A) flying only five months later, on 19 May 1948, entering USAF service from February 1949, a few weeks before its Soviet contemporary joined the VVS. By this time, the Sabre had already been committed to a process of development and incremental redesign which, over the years, was to result in a dozen major model changes and adaptation for five different turbojets. To be licence-built in four countries, it was to serve with more than two dozen air forces and it was to be manufactured continuously for 13 years—the last being assembled in Japan in February 1961, with 8,732 being built in its multifarious land-based forms, plus 1,112 examples of shipboard models.

The first production fighter capable of attaining supersonic speed in a dive (Mach 1·0 being reached easily within about 5,000 ft (1,525 m) from a dive commenced at 36,000 ft (10,975 m)), the Sabre was, nevertheless, somewhat underpowered, and while a good gun platform in perpetuating the use of six fifties it was deficient in firepower. Committed to the Korean conflict with the operational debut of the MiG-15, its superlative handling qualities and genuine transonic capabilities compensated for inferiority in acceleration, manoeuvrability and altitude performance by comparison with its Soviet adversary.

The F-86E model with all-flying tail which appeared in 1951 eliminated many of the F-86A's undesirable compressibility effects. Its only limitation was its pilot's tolerance rather than that of the airframe, and it was one of the few fighters of its generation that could be termed vicious.



SPECIFICATION: F-86E Sabre

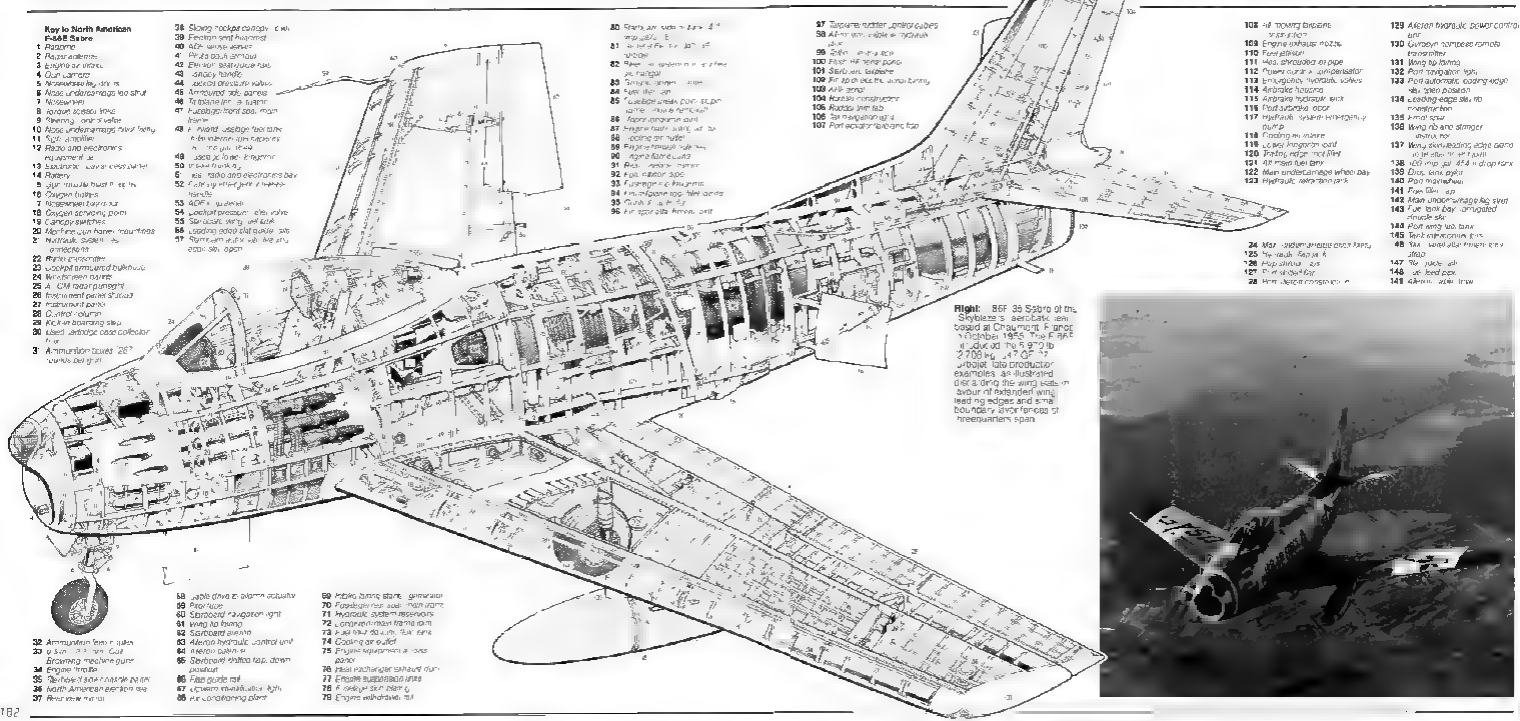
Power Plant: One General Electric J47-GE-13 axial-flow turbojet rated at 5,200 lb (2,359 kg). Internal fuel capacity 379·5 Imp gal (1,725 l), with provision for two 173·7 Imp gal (790 l) drop tanks.

Performance: Max speed, 679 mph (1,093 km/h) at sea level, 601 mph (967 km/h) at 35,000 ft (10,670 m); average cruise, 537 mph (864 km/h); initial climb, 7,250 ft/min (36·83 m/sec); time to 30,000 ft (9,145 m), 6·3 min; service ceiling, 47,200 ft (14,385 m); combat radius (internal fuel), 321 mls (517 km), with drop tanks), 424 mls (682 km); ferry range, 1,022 mls (1,645 km).

Weights: Empty, 10,845 lb (4,919 kg); loaded (clean), 14,856 lb (6,739 kg); max, 17,806 lb (8,077 kg).

Dimensions: Span, 37 ft 1½ in (11·31 m); length, 37 ft 6½ in (11·44 m); height, 14 ft 9½ in (4,51 m); wing area, 287·9 sq ft (26·74 m²).

Armament: Six 0·50-in (12·7-mm) Colt-Browning M-3 machine guns with 267 rounds of ammunition for each gun, with provision for two 1,000-lb (453,6-kg) bombs or sixteen 5-in (127-mm) rockets.



Right: F-86E-35 Sabre of the Skyblazers aerobatic team based at Chaumont, France, in October 1953. The F-86E introduced the 6,000-lb (2,709-kg) J47-GE-27 turbojet, late production examples also illustrated dive brake on the wing leading edge, a feature of extended wing, leading edges and small boundary layer forces at three-quarters span.

Mikoyan-Gurevich MiG-15 (December 1947)

To be numbered among the most significant warplanes in the history of military aviation the MiG-15, together with its US counterpart the F-86 Sabre (see pages 182-183) represented a radical advance in fighter technology and initiated what was to be seen as a second generation in jet fighter development. Both were brilliant designs evolved contemporaneously. The prototype of the US fighter flying exactly 13 weeks before the Soviet fighter. Both were to manifest clear advantages and disadvantages when compared one with the other but the comparative losses that they were to sustain when pitted in combat over Korea were to give a misleading impression of their relative capabilities.

In Korea the overriding factor was the higher standard of training of the Sabre-mounted USAF pilots. Flown by equally proficient pilots, the outcome of any encounter between Sabre and MiG-15 would have depended on a combinat on of attitude and opportunity to exploit their differing characteristics. Smaller and lighter than its US counterpart, with an appreciably better thrust-to-weight ratio, the MiG-15 was the less sophisticated aeroplane from the equipment view point, and conceived for high-altitude bomber interception with armament optimised for this task it was not ideally suited for fighter-versus-fighter combat and was thus at a disadvantage in the type of mêlée to which it was committed in the Korean War, 1950-1953.

It was capable of out-climbing and out-manoeuvring the Sabre however, and it offered better acceleration. Furthermore it had several thousand feet in hand when the US fighter ran out of ceiling. Conversely, the MiG-15 suffered directional snaking above Mach 0·86 and displayed a tendency to drop a wing and flick into a spin if forced o manoeuvre at medium altitudes. The F-86 Sabre, unlike its Soviet counterpart did possess a genuinely transonic airframe its handling at transonic speeds endowed it with a definite superiority as a gun platform and the ability to lose its opponent in a dive.

Conceived to meet a specification formulated in March 1946 the first prototype of the MiG-15 flew on 30 December 1947 as the I-310 with an imported Rolls-Royce Nene 2 engine. Various design revisions resulted in the Type S, this series entering production mid-March 1948, with service deliveries commencing in spring 1949. Many variants of the basic Type S MiG-15 followed, most important being the Type SD MiG-15bis with the RD-45F-derived 5,952 lb (2 700 kg) VK-1 engine which was to be built in larger numbers than any jet fighter before or since.

SPECIFICATION, MiG-15 (Type S)

Power Plant One Klimov RD-45F (Rolls-Royce Nene derivative), centrifugal turbojet rated at 5,005 lb (2 270 kg) static thrust. Internal fuel capacity, 321 Imp gal (1 460 ...

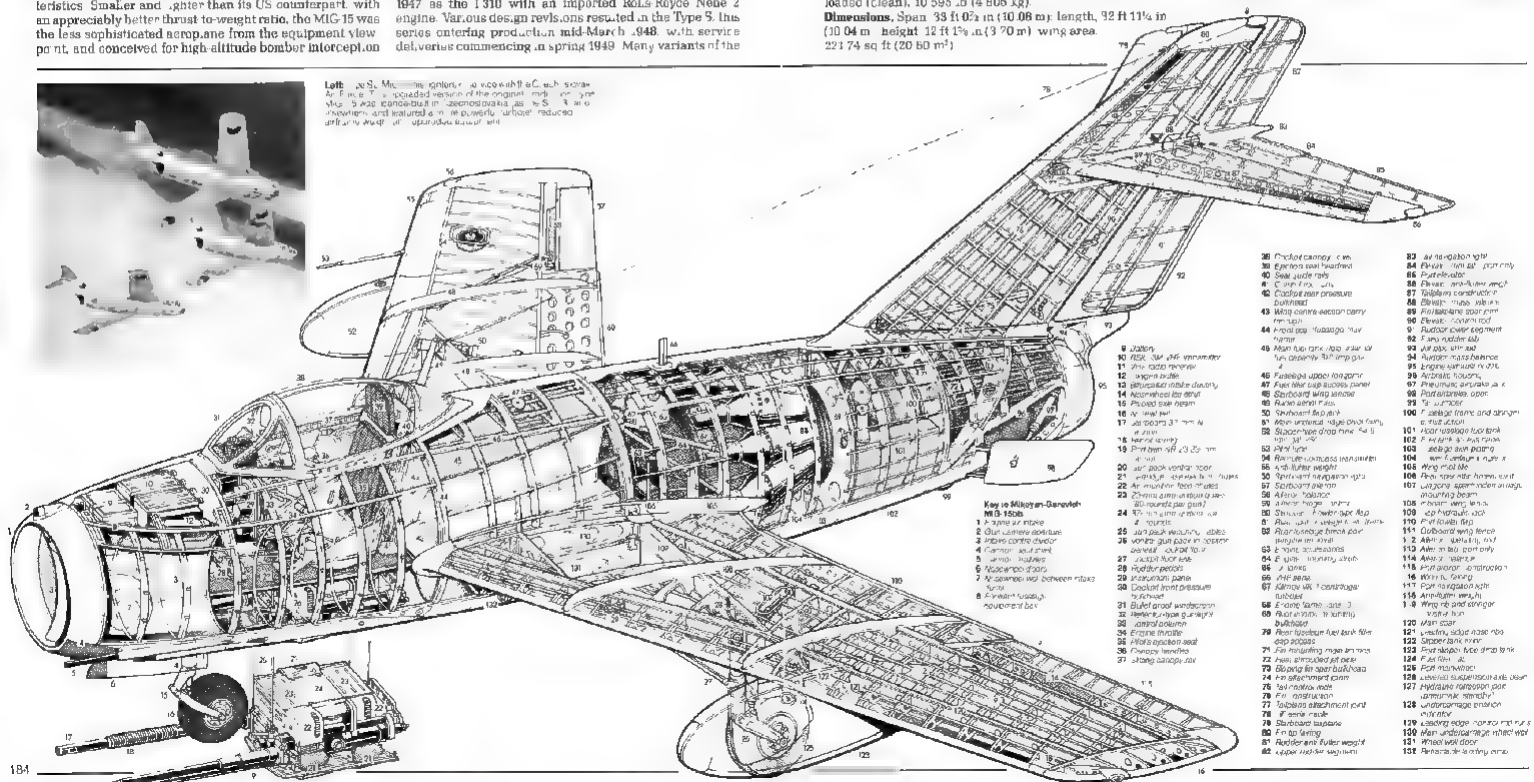
Performance Max speed 652 mph (1 050 km/h) at sea level 648 mph (1 043 km/h) at 9,840 ft (3 000 m), 640 mph (1 031 km/h) at 16,405 ft (5 000 m), 623 mph (1 004 km/h) at 26,245 ft (8 000 m) range, 882 miles (1 420 km) at 335 mph (360 km/h) at 49 370 ft (15 000 m), with two 54·4 Imp gal (247·5 l) drop tanks, 1,182 miles (1 920 km). Initial climb 8,268 ft/min (42 m/sec).

Weights: Empty equipped 7,450 lb (3 382 kg) normal loaded (clean), 10 595 lb (4 808 kg).

Dimensions, Span 33 ft 0½ in (10·06 m) length, 32 ft 11¼ in (10·04 m) height 12 ft 1⅝ in (3·70 m) wing area, 221·74 sq ft (20·60 m²)

Armament: One 37-mm Nudelman N-37 cannon with 40 rounds and two 23-mm Nudelman-Suranov NS-23KM cannon with 80 rpg

Left ...o S. Mi... ...ion ... with a C... ...
Air Force T... ...upgraded version of the original ... ...
MiG-15 was ...-built in Czechoslovakia as the S... ...
...nowhere and featured a more powerful airframe reduced ...
...



Avro Canada CF-100 Canuck (January 1950)

Left: A CF-100 Mk 5, the definitive production version, of the Canuck [illegible] with wingtip rocket pods.

The issue by the Canadian Department of National Defence late in 1945 of requirement AIR-7-1 introduced a new factor [illegible] fighter design equation: optimisation for a specific combination of [illegible] and geographic conditions. AIR-7-1 was not unusual in calling for a twin-engined two-seat fighter possessing around the clock all-weather capability, but it included some particularly demanding aspects. In order to provide in-depth defence of Canada's immense Arctic [illegible] AIR-7-1 called for an operational radius of at least 750 miles (1 207 km) including 15 min combat, on internal fuel; the fighter had to operate over an ambient air temperature range of −57°C to +45°C, and it had to be able to utilise austere and confined bases in the most adverse weather.

The era of the all-weather turbojet fighter having barely dawned, it was hardly surprising that a combat aircraft capable of fulfilling AIR-7-1 was neither in existence nor prospect. What was surprising was Canada's decision to develop a warplane tailored to AIR-7-1 as a national programme. This was to emerge four years later in the shape of the CF-100 which was to be deceptively conservative in aerodynamic configuration.

Designed by a team headed by John Frost and first flown on 19 January 1950, the CF-100 featured twin turbojets surrounding the crew cockpit units and flanking a slim circular-section fuselage into which they were faired to produce an almost aerofoil-section central body contributing 30 per cent of the total lift. The first series version, the Mk 3 (70 built), flew on 11 October 1952 and was succeeded by the 6,455-lb (2 882-kg) Orenda-powered Mk 4A and 7,275-lb (3 300-kg) Orenda 11-powered Mk 4B, the former (137 built) retaining the Mk 3's ventral tray of eight 0·50-in (12,7-mm) M-3 guns, and the latter (144 built) having a ventral rocket pack as an option, both mounting wingtip rocket pods. The definitive model, the Mk 5 (329 built), featured a 8-ft (1,83-m) wing extension and discarded the ventral pack in favour of larger wingtip pods; production ending late 1958.

SPECIFICATION: CF 100 Mk 5

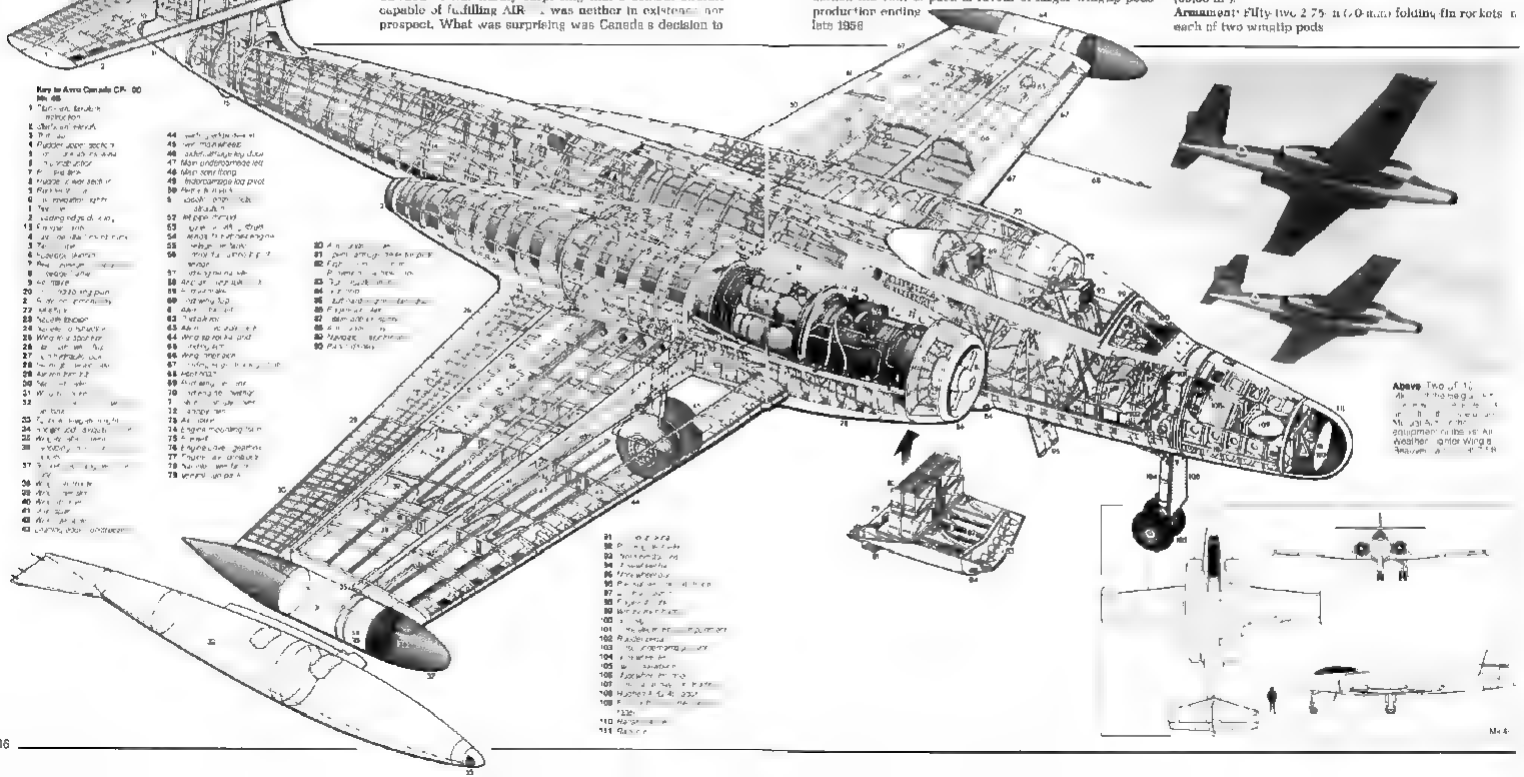
Power Plant: Two Avro Orenda Mk 14 axial-flow turbojets each rated at 7 275 lb (3 700 kg). Internal fuel capacity 1,350 Imp gal (6 137 l), with provision for two 243 Imp gal (1 105 l) wingtip tanks.

Performance: Max speed 1 241 mph (1 994 km/h) at sea level, 530 mph (853 km/h) at 5 000 ft (1 525 m), 560 mph (901 km/h) or M 0·85 at 40 000 ft (12 190 m); range cruise 447 mph (722 km/h) or M 0·68 at 36 000 ft (10 975 m); initial climb 6 500 ft/min (33,2 m/sec). Time to 40 000 ft (12 190 m) 8·0 min; combat radius (internal fuel), 700 mls (1,126 km); max range (with wingtip tanks) 2 500 mls (3 700 km).

Weights: Empty 23,100 lb (10 478 kg); normal loaded 33 600 lb (15 240 kg); max 36 485 lb (16 540 kg).

Dimensions: Span (over pods) 60 ft 10¼ in (18,55 m) (without pods) 57 ft 2½ in (17 42 m); length 54 ft 1¾ in (16,50 m); height 14 ft 6 in (4 42 m); wing area 578 14 sq ft (53,80 m²).

Armament: Fifty-two 2·75-in (70-mm) folding-fin rockets in each of two wingtip pods.



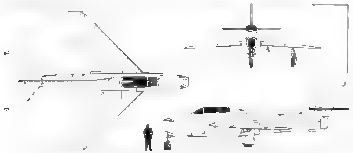
Republic F-84F Thunderstreak (June 1950)

With practicability of wing sweepback proven as a means of delaying compressibility onset, studies were made of its application to a variety of existing straight wing fighters as potentially economical means of enhancing performance. Most such were of dubious feasibility, and, in the event, only two of US origin were pursued to the extent that production derivatives resulted: the F9F Cougar (see pages 192-193), and the F-84F Thunderstreak. Insofar as the latter was concerned, however, incremental redesign prior to production was to produce a fundamentally new aeroplane, retaining no commonality with its precursor the F-84E Thunderjet (see pages 178-179).

Conceived during a period of acute government parsimony towards new warplane development, the F-84F stemmed from a late 1949 proposal to mate the fuselage of the existing F-84E with new swept surfaces, thus offering a substantial performance increment yet utilising up to 80 per cent of existing tooling. This union was duly flown as the XF-84F on 3 June 1950, but in order to take full advantage of its more advanced aerodynamic characteristics, redesign of the fuselage was undertaken to permit installation of the more powerful Wright J65 turbojet equipped with which a further prototype, designated the YF-84F, flew on 14 February 1951.

Numerous additional changes eradicated the last commonality with the F-84E before the first production F-84F flew on 14 February 1951, service phase-in by the USAF commencing in 1954. Optimised for the fighter-bomber mission, the F-84F proved exceptionally demanding on field length and, at the time of its service debut, its landing speed was considered dauntingly high. Underpowered with external loads, the F-84F tended to wallow in the climb-out, lacked acceleration and was particularly susceptible to high speed stalling. Some of its less pleasant handling characteristics were alleviated with the introduction of an "all flying" tail with the 275th (F-86F-25) and subsequent aircraft, and it was to prove an exceptionally rugged aircraft, a stable weapons platform and capable of lifting formidable stores loads.

A total of 2,711 F-84F Thunderstreaks was built, 1,301 of these being supplied to NATO air forces from 1955 and serving until the early seventies.



SPECIFICATION: F-84F-50 Thunderstreak

Power Plant: One Wright J65-W-7 axial-flow turbojet rated at 7,800 lb (3,538 kg). Internal fuel capacity: 475 Imp gal (2,159 l); with provision for two 191.5 Imp gal (870 l) or 375 Imp gal (1,705 l) drop tanks, or (for ferrying) two of each.

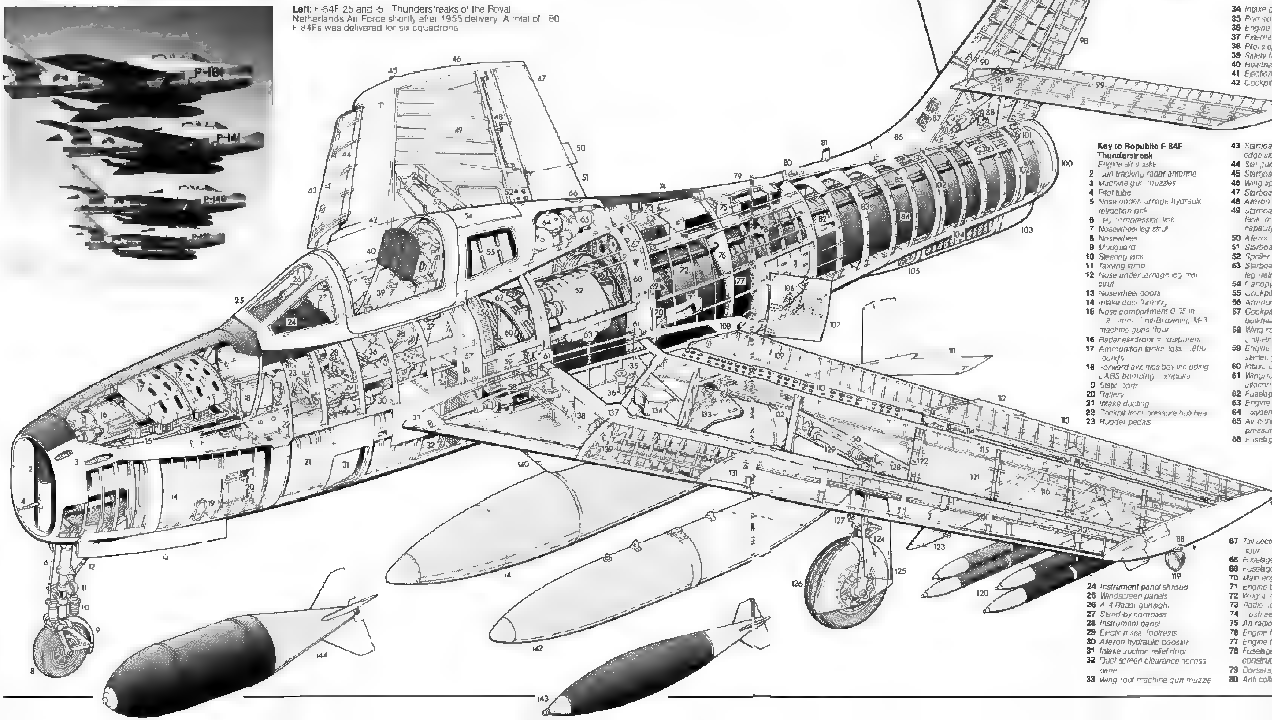
Performance: Max speed: 658 mph (1,059 km/h) or M 0.864 at sea level; 612 mph (985 km/h) or M 0.92 at 35,000 ft (10,670 m); max cruise: 539 mph (867 km/h); combat radius (two 375 Imp gal/1,705 l drop tanks): 850 mls (1,375 km); ferry range (max external fuel): 2,343 mls (3,770 km); initial climb: 7,400 ft/min (37.59 m/sec); time to 35,000 ft (10,670 m): 7.2 min; combat ceiling: 44,850 ft (13,670 m).

Weights: Empty: 13,845 lb (6,189 kg); combat: 18,700 lb (8,482 kg); normal loaded: 25,226 lb (11,442 kg); max: 27,000 lb (12,247 kg).

Dimensions: Span: 33 ft 7¼ in (10.24 m); length: 43 ft 4¾ in (13.23 m); height: 15 ft 0 in (4.57 m); wing area: 325.09 ft² (30.19 m²).

Armament: Six 0.50 in (12.7 mm) Colt Browning M-3 machine guns with 300 rpg, and provision for up to 6,000 lb (2,722 kg) of external ordnance.

Left: F-84F 25 and 45 Thunderstreaks of the Royal Netherlands Air Force shortly after 1955 delivery. A total of 80 F-84Fs was delivered for six squadrons.



Key to Republic F-84F Thunderstreak

Engine air intake
2 Jet engine room amplifier
3 Machine gun muzzles
4 Pitot tube
5 Nose wheel strut hydraulic retraction jack
6 Nose compartment lens
7 Nosewheel leg strut
8 Nosewheel
9 Mudguard
10 Steering arm
11 Towing arms
12 Nose wheel strut leg rear pivot
13 Nosewheel doors
14 Intake duct fairing
15 Nose compartment O-2E in (8 mm) Mk-18 Browning M-3 machine guns (port)
16 Rangefinder transmitter
17 Ammunition belts (port side)
18 Forward avionics bay including ARBS bombsight
19 Cable loom
20 Radom
21 Wheel housing
22 Tailpipe from pressure bulkhead
23 Rudder pedals
24 Instrument panel shroud
25 Windscreen panels
26 A-1 Radar gunsight
27 Standby compass
28 Instrument panel
29 Engine air bleed hose
30 Aileron hydraulic booster
31 Rudder pedal relighting
32 Duct screen clearance across spine
33 Wing root machine gun muzzle
34 Intake duct screen
35 Pitot tube (port side)
36 Engine throttle
37 Fuselage drop tank release handle
38 Pilot's ejection seat
39 Safety harness
40 Rudder
41 Rudder link guide rails
42 Cockpit canopy cover
43 Starboard aileron trailing edge, outboard section
44 Starboard flap
45 Starboard navigation light
46 Wing up fairing
47 Starboard aileron
48 Aileron hinge bracket
49 Starboard wing integral fuel tank, inner gun mounting bay, rear spar
50 Aileron control jack
51 Starboard tip
52 Spoiler
53 Starboard main undercarriage leg, retracted position
54 Landing lamp hinge arm
55 Wing root jet pipe
56 Aerodynamic leak duct
57 Cockpit pressure bulkhead
58 Wing root (port) gun muzzle
59 Engine electric terminal
60 Intake compressor fan
61 Wing root leg side bracket, upper rear half shell
62 Fuselage main up locks
63 Engine oil tank
64 Wing root spar
65 Air conditioning and pressurisation ducts
66 Fuselage fuel tank filler cap
67 Tailplane attachment bolts
68 Fuselage purple main frames
69 Fuselage break point
70 Main engine mounting
71 Engine bay cooling intake
72 Engine drive gearbox
73 Radio compass antenna
74 Wing root fairing
75 Air radio equipment bay
76 Engine forward
77 Engine turbine section
78 Fuselage frame and stringer construction
79 Dorsal spine fairing
80 Anti collision light
81 VHF aerial
82 Wing root fairing panels
83 Rear fuselage fairing
84 Jet pipe
85 Rudder compensator (port side)
86 Fin root fillet
87 Aerial fairing strip
88 Fin spar
89 Fin tailplane closing plates
91 Spar cap of fin fairing
92 Fin leading edge
93 Rudder construction
94 Rudder mass balance weights
95 Fin tip aerial fairing
96 Fin tailplane fairing
97 Rudder trim actuator
98 Rudder fixed tab
99 Rudder control jack mounting
100 Rudder control cable
101 Rudder hinge fairing
102 Tailplane attachment plates
103 Rudder control cable fairing
104 Rudder hinge blade
105 Fixed fin leading edge
106 Aerial fairing (port side)
107 Fin attachment bolts
108 Tailplane leading edge
109 Port tailplane
110 Port tailplane
111 Elevator control arm
112 Port tailplane
113 Port elevator
114 Aileron hinge brackets
115 Port aileron
116 Port aileron trailing edge
117 Wing tip fairing
118 Port navigation light
119 Retractable landing lamp
120 Port 2.75 in (68 mm) FFAR rocket pods
121 Wing, port side
122 Wing root, port side
123 Port aileron hinge brackets
124 Aileron control jack for port aileron
125 Aileron trim
126 Port navigation
127 Main undercarriage leg strut
128 Undercarriage leg pivot fairing
129 Hydraulic retraction jack
130 Main undercarriage mounting beam
131 Port undercarriage leg/fuselage fairing
132 Mainwheel well
133 Fuselage wheel door
134 Wing doors in flight retracting actuator linkage
135 Wing root leg fairing
136 Aerial engine access door
137 Fuel gauge
138 Intake frame
139 Inner leading edge, port wing
140 Inboard panel
141 [illegible]
142 [illegible]
143 [illegible]
144 [illegible] Rocket weapon

Hawker Hunter (July 1951)

Acknowledged as the classic single-seat fighter of the fifties, the aesthetically-unsurpassed Hunter was the first genuinely transonic British service aircraft. First flown on 21 July 1951, the Hunter suffered a somewhat protracted gestation and did not enter the RAF in its initial F Mk 1 service form for three years, until July 1954. Even then, serious teething problems remained to be resolved, such as pitch-up ineffectiva longitudinal control at high speed and engine surging and pitch-down during gun firing, but its fundamental shortcoming, inadequate internal fuel tank capacity, was insoluble.

The principal problems were eradicated and the fuel problem was mitigated with the F Mk 4, which flew on 20 October 1954 by a nominal increase in internal capacity and provision for drop tanks, and the Hunter began to establish a reputation as a "pilot's aeroplane" in every respect. It was to prove to grant to most kinds of abuse, offering flawless handling with very few limitations, and its relatively low wing loading and, for its day, comparatively high power-to-weight ratio rendered it an exhilarating aircraft to fly.

Extraordinarily robust, a fact belied by its fine contours, the Hunter was to see almost two decades of first line RAF service. Its last operations, prior to being those of ground attack and tactical reconnaissance as the FGA Mk 9 and FR Mk 10 respectively, these both being conversions of the definitive F Mk 6 series, production of which had entered service from June 1956. Production of the Hunter was to continue into 1959, with a total of 1,972 being completed, of which 445 were licence-built in Belgium and the Netherlands. Of those, almost one-third were later be refurbished and converted for a variety of roles for the RAF and a dozen overseas customers.

SPECIFICATION: Hunter F Mk 6

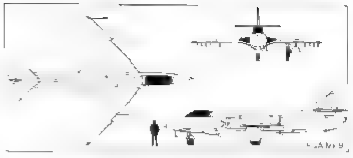
Power Plant: One Rolls-Royce Avon 207 axial-flow turbojet rated at 10,150 lb (4,605 kg) static thrust. Internal fuel capacity, 362 Imp gal (1,782 l), with provision for four 100 Imp gal (455 l) or two 230 Imp gal (1,046 l), and two 100 Imp gal (455 l) drop tanks.

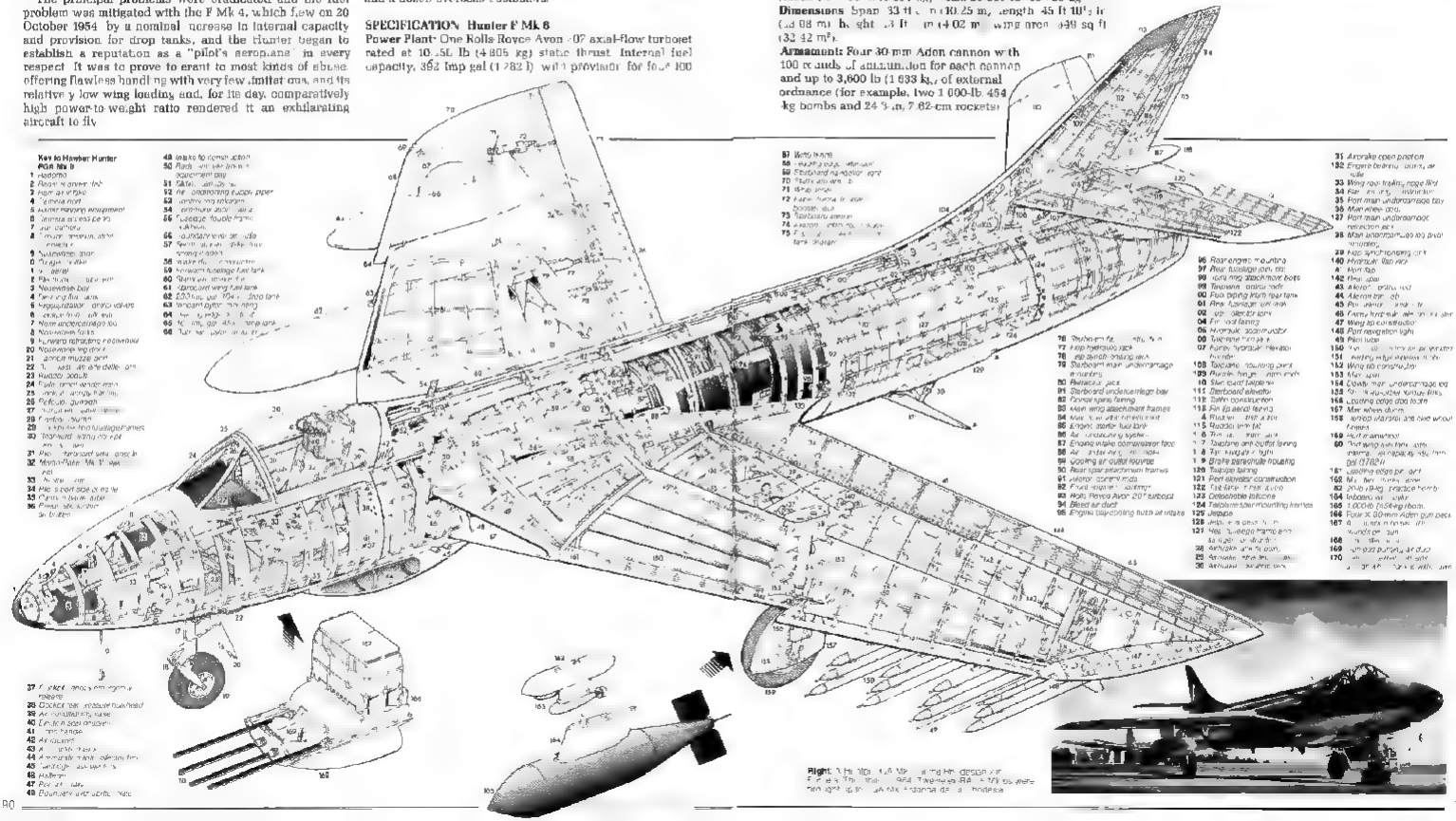
Performance: Max speed, 715 mph (1,150 km/h) or M=0.938 at sea level, 623 mph (1,002 km/h) or M=0.945 at 36,000 ft (10,975 m); tactical radius (internal fuel, high-altitude interceptor mission), 228 mls (367 km); [illegible] with 24 x 3 in 7.62-cm rockets and two 230 Imp gal (1,046 l) drop tanks, 443 mls (713 km); ferry range (max external fuel), 1,900 mls (3,058 km); initial climb, 17,200 ft/min (87.37 m/sec); time to 40,000 ft (12,190 m), 4.95 min.

Weights: Empty equipped, 14,122 lb (6,405 kg); loaded (clean), 17,750 lb (8,051 kg); max, 23,830 lb (10,796 kg).

Dimensions: Span, 33 ft 8 in (10.25 m); length, 45 ft 10½ in (13.98 m); height, 13 ft 2 in (4.02 m); wing area, 349 sq ft (32.42 m²).

Armament: Four 30-mm Aden cannon with 100 rounds of ammunition for each cannon and up to 3,600 lb (1,633 kg) of external ordnance (for example, two 1,000-lb (454-kg) bombs and 24 x 3-in 7.62-cm rockets).





Key to Hawker Hunter FGA Mk 9

1 Radome
2 Radar scanner
3 Radar antenna
4 Electronic equipment
5 Gunsight
6 Pitot tube
7 Port cannon
8 Nosewheel bay
9 Forward fuselage fuel tank
10 Hydraulic [illegible]
11 Nosewheel leg
12 Nosewheel door
13 Cannon muzzle port
14 [illegible]
15 Rudder pedals
16 Control column
17 Instrument panel
18 Windscreen
19 Rear-view mirror
20 Nosewheel door
21 Cannon muzzle port
22 [illegible]
23 Rudder pedal
24 Control column
25 Instrument panel
26 Gunsight
27 Windscreen
28 Rear-view mirror
29 [illegible]
30 Port hydraulic reservoir
31 Main-plate Mk 17 ejection seat
32 Main-plate Mk 17 ejection seat
33 [illegible]
34 Pilot's seat back armour
35 Pilot's back armour
36 Pilot's seat adjuster
37 [illegible]
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49 Brake lip [illegible]
50 Rear [illegible] equipment bay
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96 Rear engine mounting
97 Rear fuselage [illegible]
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109 [illegible]
110 [illegible]
111 Starboard elevator
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Flight: [illegible]

Grumman F9F (F-9) Cougar (September 1951)

USA

With the adoption of wing sweepback for land-based fighters, designers of shipboard counterparts began to evaluate the effects of this development on their future progeny. The swept wing at first appeared incompatible with carrier requirements. It increased dihedral effect, decreased damping in roll, and it adversely affected the relationship between adverse yaw due to rolling and the stability of the aircraft. Furthermore, there seemed little likelihood that the swept wing could offer acceptable carrier approach speeds.

After protracted evaluation of the problems, Grumman Aircraft Engineering decided to adopt the most economical and low-risk solution to the development of a swept wing carrier fighter by emulating Republic Aviation and applying sweep-back to an existing aircraft with unswept surfaces. The subject of this development was the F9F-5 Panther, which had become the first naval jet fighter to see combat when it began Korean operations on 3 July 1950. The problem of approach speeds had been resolved with the Panther by combining leading-edge slats with trailing-edge flaps. This arrangement was retained for its swept-wing derivative but the chord of the slats was increased and the flaps were extended along three-quarters of the span. The ailerons were supplanted by upper-surface spoilers and fences were added to reduce spanwise flow.

Within the phenomenally short time of six months a swept wing prototype, the XF9F-6 was completed and flown on 20 September 1951. This retained the fuselage and vertical tail surfaces of the F9F-5 Panther and the first production deliveries to the US Navy began as the F9F-6 Cougar barely more than three months later.

The flying characteristics of the Cougar remained essentially similar to those of the Panther. Handling was pleasant, control response was good. It was relatively stable and there were no significant restrictions on flight manoeuvres and stalling speeds were virtually identical. But whereas the Panther had a critical Mach number of 0.69, which it could only reach in a dive accompanied by severe buffet and almost uncontrollable pitch-up, its more practical limitation being Mach = 0.79, the F9F-6 could attain Mach 0.88 at sea level and 0.895 at 35,000 ft (10,670 m) level flight.

The first service shipboard swept-wing fighter, the F9F-6 (253 built) was followed by the F9F-7 (168 built) with the J48-P-8 (3,250 lb (3,152 kg) Allison J33-A-16 the definitive fighter model being the F9F-8 (601 built) which first flown on 19 December 1953, introduced an 8-in (20-cm) fuselage extension to increase internal fuel capacity, discarded the slats to permit installation of leading-edge tanks, and had a 5 per cent wing chord increase to improve the critical Mach number by providing a relatively thinner section. In 196.. the F9F was redesignated F-9. A training variant (TF-9) remained in service until early in 1974.

SPECIFICATION F9F-8 (F-9) Cougar

Power Plant: One Pratt & Whitney J48-P-8 centrifugal-flow turbojet rated at 7,250 lb (3,288 kg) static thrust. Internal fuel capacity, 885 Imp gal (4,024 l), with provision for two 125 Imp gal (568 l) drop tanks.

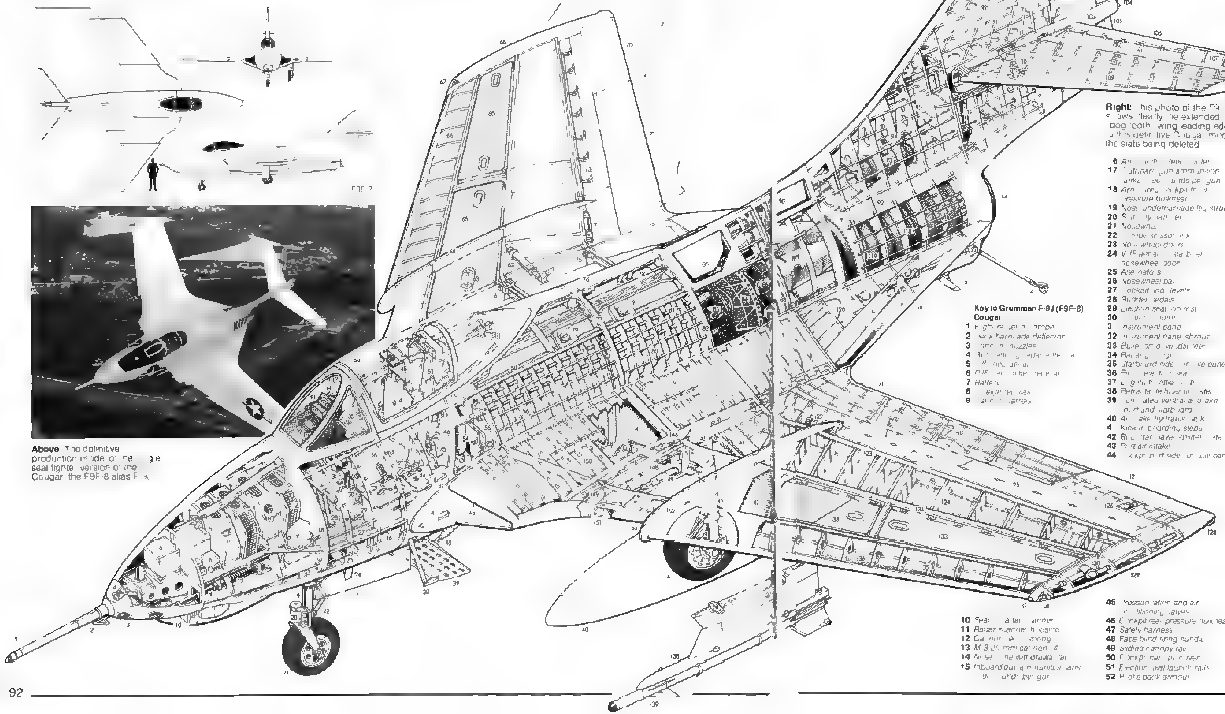
Performance. Max speed, 642 mph (1,033 km/h) or M=0.84; combat radius, 443 mls (713 km); range (internal fuel), 1,209 mls (1,946 km) at 516 mph (830 km/h) at 38,000-42,000 ft (11,580-12,800 m), initial climb, 4,800 ft/min (24.38 m/sec); time to 20,000 ft (6,095 m), 4.6 min, to 30,000 ft (9,145 m), 8.3 min; service ceiling, 42,000 ft (12,800 m).

Weights. Empty, 11,666 lb (5,382 kg); normal loaded (clean), 20,098 lb (9,118 kg); maximum gross weight, 24,763 lb (11,232 kg).

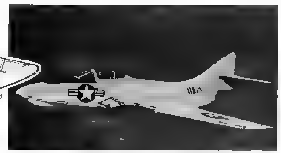
Dimensions Span, 34 ft 6 in (10.51 m); length, 42 ft 2 in (12.85 m); height, 12 ft 2½ in (3.72 m); wing area, 337 sq ft (31.30 m²).

Armament Four 20-mm M-3 cannon with 190 rounds of ammunition per gun and provision for two AIM-9 Sidewinder air-to-air missiles or up to four 500-lb (226.8-kg) bombs.

Above: The definitive production version of the carrier-based fighter, variously known as the Cougar, the F9F-8 and F-9.



Right: This photo of the F9F-8 shows how the extended deep-cloth wing leading-edge with the slats being deleted.



Key to Grumman F-9J (F9F-8) Cougar

1 Pitot tube
2 Nose radome
3 Nose compartment
4 Nose wheel doors
5 Nose wheel
6 Nose wheel mounting
7 Nose wheel retracted position
8 Nose wheel leg door
9 Rudder pedals
10 Seat
11 Radio equipment
12 Canopy
13 M-3 20-mm cannon
14 Nose wheel retraction jack
15 Rudder control linkage
16 Rudder control quadrant
17 Cockpit pressure bulkhead
18 Aft pressure bulkhead
19 Rear fuselage
20 Control linkage
21 Rudder
22 Rudder actuator
23 Rudder actuator
24 Vertical fin
25 Anti-flutter balance
26 Rudder hinges
27 Rudder
28 Tailplane
29 Tailplane actuator
30 Tailplane
31 Tailplane hinge
32 Horizontal tailplane stiffener
33 Elevator control rod
34 Elevator
35 Starboard elevator
36 Elevator hinge
37 Elevator
38 Elevator hinge
39 Tailplane and elevator control and trim jack
40 Aft fuselage
41 Rear equipment bay
42 Elevator actuator
43 Rear fuselage
44 Rear fuselage fairing
45 Tailplane actuator
46 Tailplane stiffener and actuator
47 Safety harness
48 Fore fuselage fairing
49 Starboard canopy rail
50 Canopy rail
51 Emergency canopy release
52 Hydraulic pipes
53 Control rod
54 Rear fuselage
55 Equipment bay door
56 Fore fuselage
57 Fuselage frame and skin construction
58 Aft canopy
59 Canopy actuator
60 Fairing
61 Wing root fairing
62 Wing root fairing
63 Fuselage
64 Rear spar
65 Wing main fuel tanks (inner sections, about 90 Imp gal)
66 Leading-edge slats (extended position)
67 Starboard wing root
68 Wing root
69 Starboard wing (closed position)
70 Rear spar
71 Aluminum wing skin
72 Starboard flap
73 Spar
74 Spar
75 Rear spar
76 Fuselage skin plating
77 Wing spar/fuselage main fairing
78 Fuel system piping
79 Fuel
80 Fuselage rear fuel tank
81 Rear fuselage
82 Rear fuselage main frame
83 Engine accessory compartment
84 Engine air intake screen
85 Tailplane/rear air intake doors
86 Pratt & Whitney J48-P-8A turbojet (Allison J33-A-16 in F9F-7)
87 Rear fuselage fairing (aft of main frame)
88 Engine mounting main frame
89 Engine frame
90 Secondary air intake door
91 Tailpipe fairing
92 Jet pipe heat shroud
93 Water injection tank
94 Water
95 Fuselage/aft fuselage junction
96 Tailplane mounting
97 Tailplane
98 Starboard tailplane
99 Starboard
100 Fin
101 Rudder
102 Rudder
103 Rear
104 Rear
105 Rear
106 Engine
107 Tailpipe
108 Engine
109 Rear
110 Trimming
111 Tailplane
112 Outboard
113 Jet
114 Sting-type deceleration hook
115 Retractable tailwheel
116 Wing root leading-edge
117 Aileron
118 Rear fuselage
119 Jet pipe
120 Starboard
121 Starboard
122 Starboard
123 Rear
124 Wing
125 Rear
126 Trim tab
127 Aileron
128 Fuel
129 Rear
130 Wing
131 Rear
132 Wing
133 Rear
134 Main
135 Aileron
136 Leading-edge
137 Wing
138 Main
139 AIM-9 Sidewinder missile
140 Tailplane
141 Main
142 Fin
143 Main
144 Wing
145 Main
146 Main
147 Aileron
148 Underwing
149 Wing
150 Wing
151 Landing
152 Fin
153 Leading-edge

Mikoyan-Gurevich MiG-19 (May 1952)

If overshadowed by ancestors which saw combat over Korea and descendants capable of bi-sonic performance, the MiG-19, as the first Soviet production fighter capable of sustained supersonic speed in level flight, justifies a position of some importance in combat aircraft development annals. Flown appreciably before its US contemporary, the F-100 Super Sabre (see pages 198-199), its development for production was, owing to the then existing technological limitations of the Soviet aircraft industry, perforce more leisurely. Thus, the US fighter subjected to an accelerated development tempo previously unsurpassed, was to gain the distinction of being both the first genuine supersonic fighter and the first to achieve service status.

The MiG-19 evolved from a series of experimental aeroplanes, its first genuine prototype being considered the I-360 (SM-2) flown on 27 May, 1952. It mated the centre and rear fuselage, tail, assembly and twin AM-5 engine installation of the I-340 (SM-1) MiG-17 derivative with the 55 deg swept wing and forward fuselage of the I-350 (M). The latter with a single Lyulka TR-3A engine, had first flown on 18 June 1951, but poor engine reliability and continued testing to five flights. The paired AM-5s afforded insufficient power for supersonic speed in level flight, this not being achieved until the late summer of 1953, when Mach 1.12 was attained with the aid of afterburning AM-5A engines. By this time the low-set horizontal tail arrangement first flown on the I-350-M had been adopted and pre-series production initiated as the MiG-19F.

The pre-series aircraft presented numerous problems, the most serious being elevator ineffectiveness at high speeds and engine unreliability. Various changes were progressively introduced in a further prototype, the SM-9 flown on 5 January 1954, the incremental modifications including more powerful RD-9 engines and a slab-type all-flying horizontal tail. Large-scale production being ordered on 31 August 1955 as the MiG-19S. This basic model emerged as an extremely agile and effective day interceptor, with outstanding acceleration and manoeuvrability up to medium altitudes, although suffering somewhat critical, low-speed handling and stability. Production was phased out in the Soviet Union late 1957, and in Czechoslovakia in 1961, but continues in China (as the F-6).

SPECIFICATION: MiG-19S

Power Plant Two Tumansky RD-9B turbojets each rated at 5,732 lb (2,600 kg) thrust dry and 7,165 lb (3,250 kg) thrust with afterburning. Internal fuel capacity, 806 Imp gal (3,675 l), provision for two 167 Imp gal (760 l) drop tanks.

Performance Max speed (clean), 902 mph at 32,810 ft (10,000 m), or M=1.35, (with two drop tanks), 715 mph (1,150 km/h), or M=1.12; range cruise, 590 mph (950 km/h) at 32,810 ft (10,000 m); max range (clean), 863 mls (1,390 km) at 45,920 ft (14,000 m), 310 mls (500 km) at 3,280 ft (1,000 m) (with drop tanks), 1,366 mls (2,200 km) at 45,920 ft (14,000 m); time-to-climb, max take-off weight, 22,640 ft/min (115 m/sec); time to 32,810 ft (10,000 m), 1.85 min.

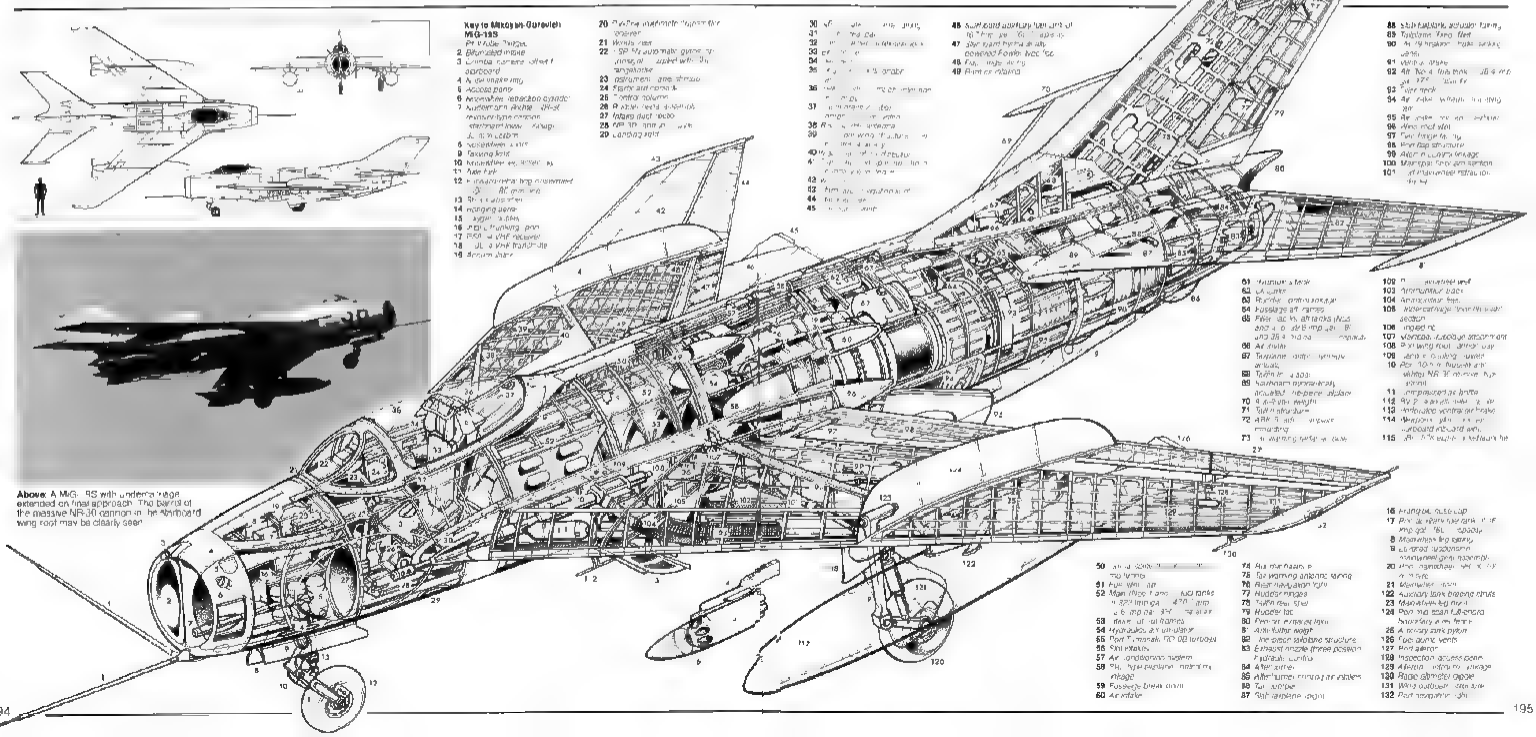
Weights Empty equipped, 11,399 lb (5,172 kg); loaded, 16,314 lb (7,400 kg); max, 19,621 lb (8,900 kg).

Dimensions Span, 29 ft 6½ in (9.00 m); length (excluding pitot), 44 ft 4 in (13.50 m); height, 12 ft 9½ in (3.90 m); wing area, 269.1 sq ft (25.00 m²).

Armament Three 30-mm Nudelman-Rikhter NR-30 cannon with 55 rounds for fuselage-mounted gun and 75 rpg for wing root weapons.

Above: [illegible] period-built MiG-19S fighters in service with the Pakistan Air Force [illegible]

Above: A MiG-19S with undercarriage extended on final approach. The barrel of the massive NR-30 cannon in the fairing of the wing root may be clearly seen.



Key to Mikoyan-Gurevich MiG-19S

1 Pitot tube
2 Starboard nose
3 Lifting camera wheel aperture
4 Nose wheel well
5 Access panel
6 Nose wheel retraction cylinder
7 Nose wheel doors, direct mounted to nose wheel
8 Nose wheel strut
9 Towing lug
10 Nose wheel [illegible]
11 Nose fork
12 [illegible] mounted [illegible]
13 [illegible]
14 Hinged [illegible]
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18 [illegible]
19 [illegible]
20 [illegible]
21 Windscreen
22 SP-5 [illegible] gunsight [illegible]
23 [illegible]
24 Frame and [illegible]
25 Control column
26 [illegible]
27 Intake duct [illegible]
28 [illegible]
29 Landing light
30 [illegible]
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46 Self-contained auxiliary fuel unit
47 [illegible]
48 [illegible]
49 Fuselage fuel tank
50 [illegible]
51 Fuel filler cap
52 Main fuel tanks
53 [illegible]
54 Hydraulic [illegible]
55 Port [illegible]
56 Skin [illegible]
57 Air conditioning system
58 [illegible]
59 Fuselage break [illegible]
60 Air [illegible]
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62 [illegible]
63 [illegible]
64 Fuselage air frames
65 Fuselage [illegible]
66 Air [illegible]
67 Tailplane [illegible]
68 Tail [illegible]
69 Aluminum [illegible]
70 [illegible]
71 Tail [illegible]
72 [illegible]
73 [illegible]
74 [illegible]
75 Top warning antenna [illegible]
76 Rear [illegible]
77 Hydraulic [illegible]
78 Tail [illegible]
79 Hydraulic [illegible]
80 [illegible]
81 Extended nozzle (three position)
82 [illegible]
83 [illegible]
84 After [illegible]
85 [illegible]
86 Tail [illegible]
87 Tail [illegible]
88 Skin [illegible]
89 Tailplane [illegible]
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115 [illegible]
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117 [illegible]
118 [illegible]
119 [illegible]
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121 [illegible]
122 Auxiliary tank [illegible]
123 [illegible]
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Dassault Mystère IV (September 1952)

Reflecting the renaissance of French combat aircraft design expertise after the lapse of a decade, the series of single-seat fighters evolved by Avions Marcel Dassault in the late forties and early fifties was destined to be overshadowed by the company's delta-winged fighter progeny that were to emerge late in the latter decade. Nevertheless, with the Mystère IVA, French fighter design could be considered to have regained international stature.

Dassault had pursued a low risk policy of incremental development in mating the fuselage of the straight-wing Ouragan, the first French jet fighter of indigenous design to attain production, with moderately swept surfaces to produce the Mystère in 1951. This was to be manufactured in limited numbers for the Armée de l'Air but possessed little more than a conceptual similarity to the Mystère IV, the appellation "Mystère" having been adopted by Dassault as a generic designation for a series of swept wing fighters. Designed to achieve genuine transonic performance the Mystère IV by comparison with the Mystère II, had quarter-chord sweepback increased from 30 to 38 degrees and the wing thickness-chord ratio reduced from 9·0 to 7·5 per cent, a prototype powered by a 5,283 lb (2,850 kg) Tay 250A turbojet flying on 28 September 1954.

In April, 1953, 225 examples of the new fighter were ordered under the off-shore procurement programme as Mystère IVAs for the Armée de l'Air and a supplementary order for a further 100 was placed by the French government. In the event, this order was to be cut back and 60 of the aircraft were to be delivered to Israel, an additional 110 being ordered by India to bring total production to 411 aircraft with completion late 1956.

The Mystère IVA possessed the shortcomings of most of its contemporaries. It was underpowered and possessed inadequate internal fuel capacity. It could exceed Mach unity in a dive, transonic speeds being accompanied by buffeting and bare y controllable pitch-up, climb and acceleration were poor and directional shaking at speed reduced its value as a gun platform. When flown in combat by the Israelis in the 1956 Middle East conflict it proved inferior in climb and manoeuvrability to the MiG-15, pilot quality playing a major part in the success of the French fighter and in the Indo-Pakistan war of September 1965 the Mystère IVA was largely relegated to the close air support role particularly suited to its robust structure.

SPECIFICATION Mystère IVA

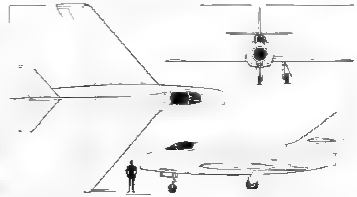
Power Plant One Hispano Suiza Verdon 350 centrifugal flow turbojet rated at 7,716 lb (3,500 kg) static thrust. Internal capacity 396 Imp gal (1,800 l), provision for two 137·5 Imp gal (625 l) or 181·5 Imp gal (825 l) drop tanks.

Performance Max speed 661 mph (1,063 km/h) or M=0·91 at sea level, 601 mph (967 km/h) or M=0·91 at 36,000 ft (10,975 m); tactical radius (internal fuel high altitude interceptor mission) 205 mls (330 km); range (internal fuel) 547 mls (880 km); max external fuel 1,019 mls (1,640 km). Max climb 8,415 ft/min (42·75 m/sec); service ceiling 42,950 ft (13,100 m).

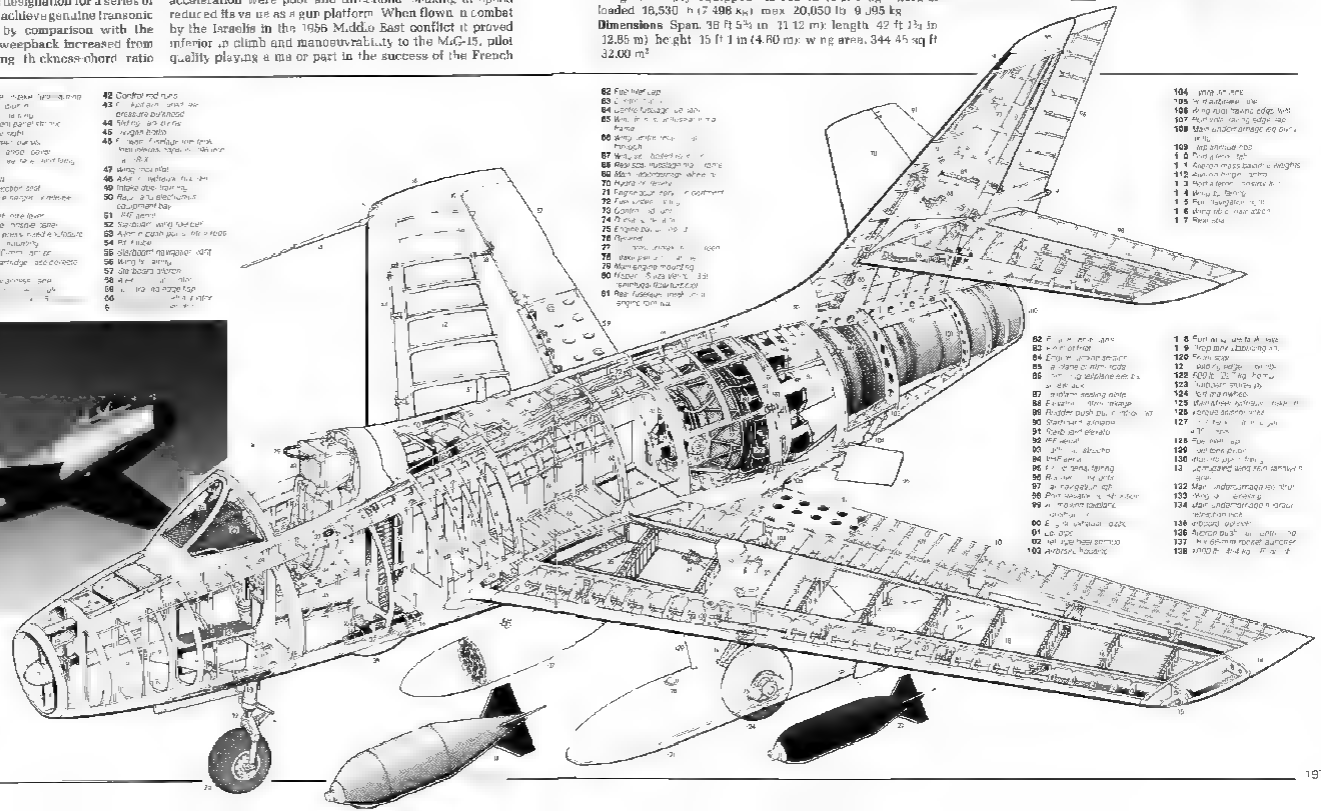
Weights Empty equipped 12,950 lb (5,874 kg); normal loaded 16,530 lb (7,498 kg); max 20,050 lb (9,095 kg).

Dimensions Span 38 ft 5¾ in (11·72 m); length 42 ft 1¾ in (12·85 m); height 15 ft 1 in (4·60 m); wing area 344·45 sq ft (32·00 m²).

Armament Two 30-mm DEFA 541 cannon with 150 rpg and provision for two 18 x 68-mm rocket pods or two 1,000-lb (453·6-kg) bombs.



Above A Mystère IVA [illegible]



North American F-100 Super Sabre (May 1953)

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Signifying a quantum advance in fighter performance when it achieved operational capability with the USAF late in September 1954, the F-100 was the world's first combat aircraft capable of sustained level flight supersonic performance, was one of the true epoch markers in fighter development annals. Noteworthy, also for the brevity of its prototype-to-production cycle, it was first flown as the YF-100A) on 25 May 1953, with the first production model, F-100A, following barely five months later on 14 October. Its Soviet counterpart, which was to evolve as the MiG-19 (see pages 194-195), in fact flew a year earlier, but the F-100 was nevertheless to be both the first combat aircraft to achieve level flight supersonic speeds and also the first to achieve service status.

Whereas the F-100A was essentially an air superiority fighter, its successor, the F-100C, featured six external ordnance stations for the fighter-bomber mission, and the definitive production model, the more sophisticated and versatile F-100D, was optimised for this role. When production terminated in October 1959, a total of 2,194 Super Sabres had been delivered.

SPECIFICATION F-100D Super Sabre

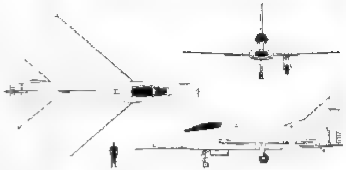
Power Plant: One Pratt & Whitney J57-P-21 or -21A axial-flow turbojet rated at 10,200 lb (4,627 kg) military dry thrust and 18,000 lb (7,258 kg) with afterburning. Internal fuel capacity, 990 Imp gal (4,500 l), with provision for two 279 Imp gal (1,268 l) and two 166.5 Imp gal (757 l) drop tanks.

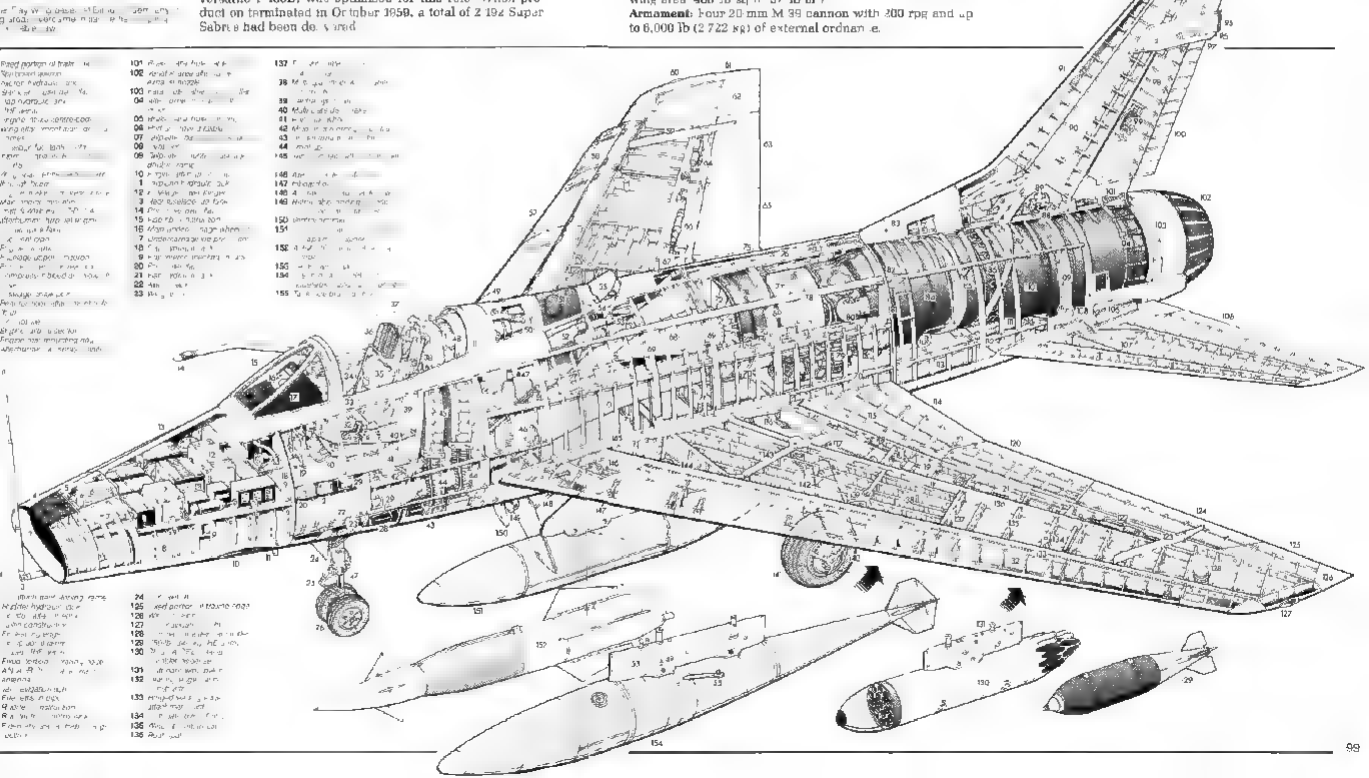
Performance: Max speed, 927 mph (1,492 km/h) or M 1.38 at 35,000 ft (10,670 m), 739 mph (1,190 km/h) or M 0.97 at sea level; max initial climb, 22,400 ft/min (113.79 m/sec); combat ceiling, 51,900 ft (15,838 m); combat radius (max external fuel), 599 mls (964 km) at 587 mph (945 km/h) at 36,500-38,000 ft (11,125-11,885 m) (internal fuel and six Mk 83 Snakeye bombs); 279 mls (448 km) ferry range (max external fuel), 971 mls (1,572 km).

Weights: Empty, 20,638 lb (9,361 kg); combat, 30,06[illegible] (13,636 kg); max, 38,048 lb (17,258 kg).

Dimensions: Span, 38 ft 9½ in (11.82 m); length (excluding pitot), 49 ft 3½ in (15.03 m); height, 16 ft 2½ in (4.94 m); wing area, 400 sq ft (37.18 m²).

Armament: Four 20 mm M-39 cannon with 200 rpg and up to 6,000 lb (2,722 kg) of external ordnance.





Key to North American F-100D Super Sabre

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Lockheed F-104 Starfighter (February 1954)

With its genesis in the Korean War, the Starfighter was first of the bi-sonic fighters generated by experience of that conflict. Original in concept, it represented a radical advance in the state of the art and few aircraft have had greater impact on fighter technology. Conceived by Clarence Johnson purely as a high altitude air superiority fighter, the Starfighter was to undergo an extraordinary metamorphosis for multi-role operation, being entirely redressed to meet new strength requirements with much external loads and to permit low-altitude missions without placard restrictions. In the process, it was to become one of the most controversial warplanes ever manufactured in quantity.

First flown (as the XF-104) on 7 February 1954, the Starfighter was characterised by a diminutive straight wing of thin (3.4 per cent) thickness-chord ratio mounted immoderately far aft on an inordinately long slim fuselage. Penalties were to be paid for its mode transformation: wing loading increasing from the 98 lb sq ft (468.71 kg/m²) of the clean F-104A interceptor to no less than 158 lb sq ft (771.42 kg/m²) for the ultimate multi-role derivative, the F-104S, in fully laden condition.

Despite fundamental unsuitability for tactical strike, the Starfighter became the subject of an immense multi-national manufacturing programme (as the F-104G) being built in Europe, Canada, as the CF-104) and Japan (as the F-104J) dedicated interceptor variant. The final model, the F-104S developed jointly by Lockheed and Aeritalia, was finally known in 1966 having a 17 900 lb (8 120 kg) GE-19 engine, additional stores pylons, provision for AIM-7 Sparrow III air-to-air missiles and a maximum weight of 31,000 lb (14 062 kg). The production of 205 aircraft was completed in Italy in the latter part of 1978. This brought the overall total of Starfighters built to 2,536, of which 737 were built by Lockheed.

SPECIFICATION: F-104G Starfighter

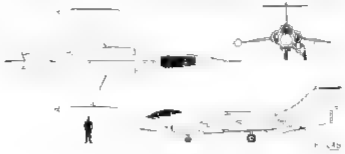
Power Plant: One General Electric J79-GE-11A turbojet rated at 10,000 lb (4 536 kg) dry thrust and 15 800 lb (7 076 kg) with afterburning. Internal fuel capacity 847.5 Imp gal (3 853 l), including 61.5 Imp gal (462 l) wing tip tank, with provision for two 283 Imp gal (1 287 l) wingtip and two 324.7 Imp gal (1 476 l) underwing drop tanks.

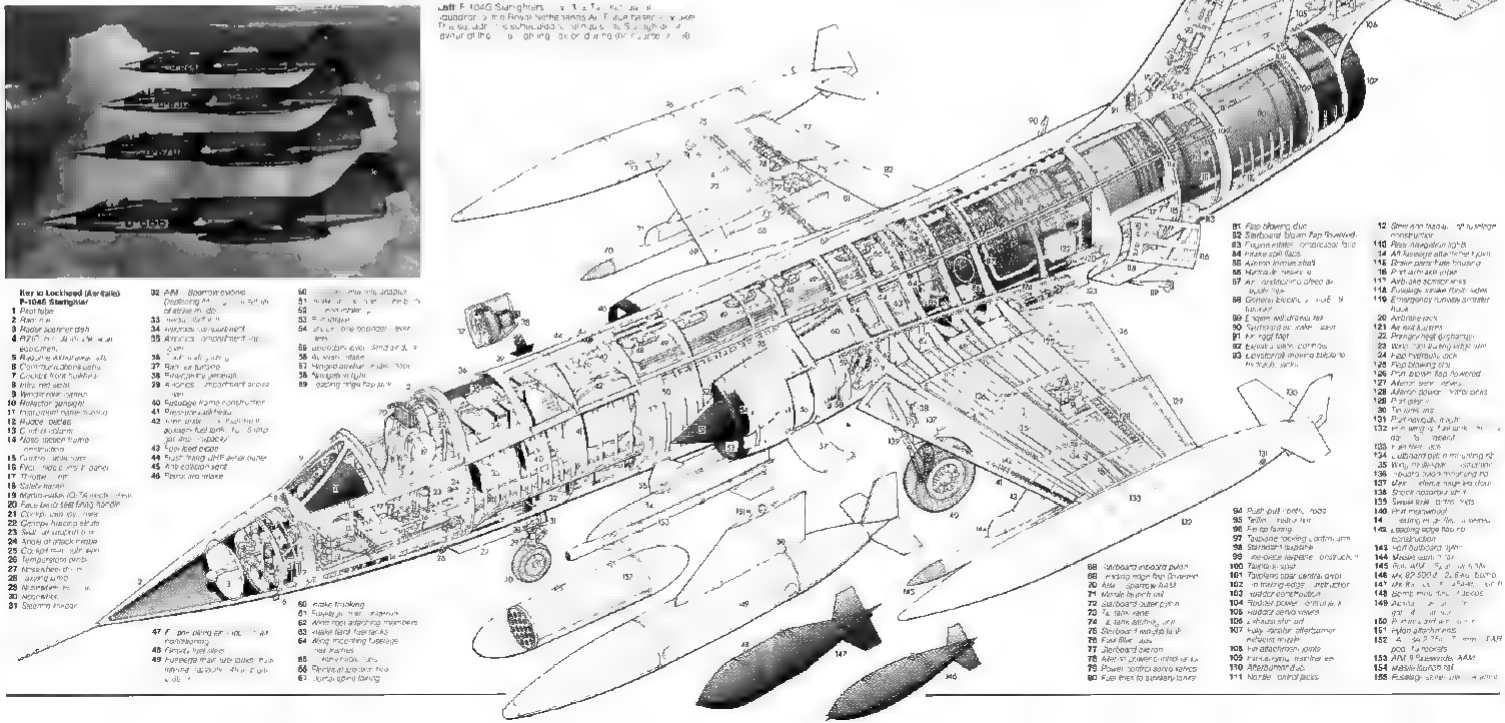
Performance: Max speed 1,328 mph (2,137 km/h) or M=2.0 at 35,000 ft (10 670 m), 850 mph (1,384 km/h) or M=1.13 at sea level; max initial climb, 48,000 ft/min (243.8 m/sec); combat ceiling 50,000 ft (15 240 m); combat radius (basic support mission with four drop tanks and two 1,000-lb (453.6-kg bombs), 619 mls (996 km) at 586 mph (943 km/h) at 21,900-33,700 ft (6 675-10 270 m), M=2.0 intercept mission, with four drop tanks), 296 mls (476 km); ferry range, 1,875 mls (3,017 km).

Weights: Empty (interceptor), 13,996 lb (6 349 kg); (fighter-bomber), 14,054 lb (6 375 kg); combat (interceptor), 20,002 lb (9 073 kg); (fighter-bomber), 20,640 lb (9 362 kg); max, 29,038 lb (13 172 kg).

Dimensions: Span, 21 ft 10¾ in (6.67 m); length, 54 ft 9½ in (16.70 m); height, 13 ft 6 in (4.11 m); wing area, 196.1 sq ft (18.2 m²).

Armament: One 20-mm M-61 rotary cannon with 725 rounds and up to 4,000 lb (1 814 kg) of external ordnance.





Left: F-104G Starfighters of the Royal Netherlands Air Force based at Leeuwarden. This squadron is scheduled to be disbanded as the Starfighter is replaced by the F-16 Fighting Falcon during the early 1980s.

Key to Lockheed (Aerfiche) F-104G Starfighter

1 Pitot tube
2 Radome
3 Radar scanner dish
4 APQ-81 radar equipment
5 Radar antenna arm
6 Communications aerial
7 Cockpit floor hatches
8 Entry hatch seal
9 Windscreen frame
10 Refector gunsight
11 Instrument panel support
12 Hydraulic detail
13 Control column
14 Nose wheel bay construction
15 Control stick grip
16 Pitot heater element
17 Throttle grip
18 Safety handle
19 Martin-Baker IC-7A ejection seat
20 Face blind SEM handle
21 Cockpit side panel
22 Canopy hydraulic strut
23 Seat adjustment crank
24 Angle of attack probe
25 Cockpit floor support
26 Temperature probe
27 Windscreen de-ice
28 Jettisoning handle
29 Windscreen de-ice
30 Microphone
31 Starboard canopy
32 AIM-9 Sparrow explosive charge
33 Nose bulkhead
34 Electronics equipment
35 Electronics compartment cooling
36 Air scoop
37 Rear air turbine
38 Emergency generator
39 Electronics equipment access
40 Fuselage frame construction
41 Equipment cooling
42 Wing root leading edge
43 Fuselage fuel tank
44 Fuselage UHF aerial outlet
45 Anti collision light
46 Barrier arrestor hook
47 Fuselage fuel tank
48 Fuselage main tube
49 Fuselage main tube
50 Rudder trimming
51 Rudder hinge
52 Rudder
53 Rudder
54 Rudder
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56 Rudder
57 Rudder
58 Rudder
59 Rudder
60 Rudder
61 Rudder
62 Rudder
63 Rudder
64 Rudder
65 Rudder
66 Rudder
67 Rudder
68 Starboard inboard pylon
69 Wing root leading edge
70 Wing root
71 Wing root
72 Wing root
73 Wing root
74 Wing root
75 Wing root
76 Wing root
77 Starboard aileron
78 Aileron power control unit
79 Power control servo valves
80 Fuel lines to auxiliary tanks
81 Flap blowing duct
82 Starboard blown flap trunnion
83 Flap operating mechanism
84 Intake spill flaps
85 Aileron torque shaft
86 Nominal hinge
87 Air conditioning duct
88 Control cables
89 Engine air duct
90 Spoiler
91 Air rigid fairing
92 Elevator control
93 Elevator control
94 Rudder
95 Rudder
96 Fin root fairing
97 Tailplane leading edge
98 Stabilator tailplane
99 Tailplane
100 Tailplane
101 Tailplane
102 Tailplane
103 Tailplane
104 Rudder power control
105 Rudder servo valves
106 Rudder
107 Fully flexible afterburner
108 Fin attachment points
109 Fin attachment points
110 Rear navigation light
111 Rear navigation light
112 Fin root
113 Fin root
114 Air passage
115 Fin root
116 Rear navigation light
117 Anti-collision light
118 Fuselage
119 Emergency rudder
120 Arrestor hook
121 Air duct
122 Pneumatic
123 Pneumatic
124 Pneumatic
125 Flap blowing duct
126 Port blown flap trunnion
127 Aileron torque shaft
128 Aileron power control
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130 Tailplane
131 Port navigation light
132 Port wing root
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140 Port wing root
141 Port wing root
142 Port wing root
143 Port outboard pylon
144 Missile launch rail
145 AIM-9P Sidewinder AAM
146 Mk 82 500-lb GP bomb
147 Mk 82 500-lb GP bomb
148 Spring mounting
149 Port wing root
150 Port wing root
151 Pylon attachment
152 Port wing root
153 AIM-9 Sidewinder AAM
154 Missile launch rail
155 Fuselage

Vought F-8 Crusader (March 1955)

Right: Two F-8A [illegible] of Western [illegible] Navy Squadron VF-[illegible] [illegible] NAS Moffett Field, California [illegible] 25 [illegible] 1964. Crusaders from [illegible] other 144 [illegible] most [illegible] 375 having [illegible] the most MiG kills of any US aircraft (3 confirmed, 1 probable) in Vietnam combat.

The first service shipboard fighter capable of genuine level flight supersonic performance, the F-8 Crusader was using [illegible] a two-position variable-incidence wing. Pivoted on the rear spar, the scoop of the raised seven degrees to provide the optimum angle of attack for launching and a broad [illegible] angle of the aggressive nose high attitudes, ensuring good pilot visibility at all times. Acceptable carrier operating speeds were achieved by combining hinged wing leading edges with inboard flaperons and conventional flaps which lowered 25 degrees to effect a increase effective camber.

The first prototype Crusader was flown (as the XF8U-1) on 25 March 1955, deliveries of the [illegible] way of superior [illegible] version (F-8A) commenced in [illegible] 1957. Successive improvements were incorporated, the definitive production model being the [illegible] F-8E, manufacture ending early 1965 with 1,261 Crusaders built. From 1966 through 1970, 551 Crusaders were reworked, remanufactured as F-8Hs from F-8Ds, F-8Js from F-8Bs, F-8Ks from F-8Cs and F-8Ls from F-8Bs, introducing boundary layer control and strengthened undercarriages.

SPECIFICATION: F-8H Crusader

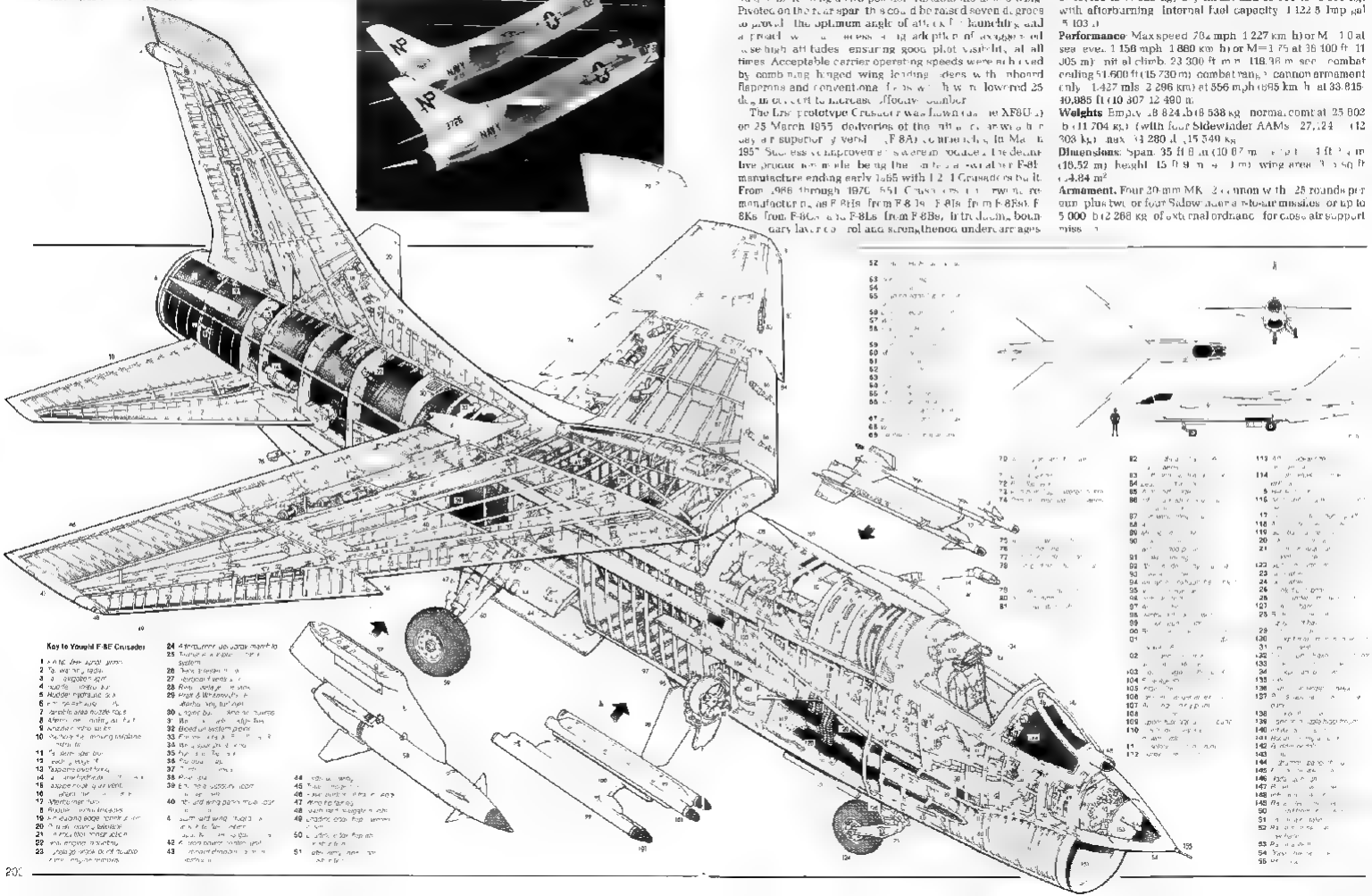
Power Plant: One Pratt & Whitney J57-P-20 turbojet rated at 12,400 lb (5,625 kg) dry thrust and 18,000 lb (8,800 kg) with afterburning. Internal fuel capacity 1,122.5 Imp gal (5,103 l).

Performance: Max speed 764 mph (1,227 km/h) or M=1.0 at sea level, 1,158 mph (1,860 km/h) or M=1.75 at 36,100 ft (11,005 m); initial climb 23,300 ft/min (118.36 m/sec); combat ceiling 51,600 ft (15,730 m); combat range, cannon armament only, 1,427 mls (2,296 km) at 556 mph (895 km/h) at 33,815-40,985 ft (10,307-12,490 m).

Weights: Empty 18,824 lb (8,538 kg); normal combat 25,802 lb (11,704 kg) (with four Sidewinder AAMs 27,224 lb (12,303 kg)); max [illegible] 34,280 lb (15,549 kg).

Dimensions: Span 35 ft 8 in (10.87 m); length 54 ft 7 in (16.64 m); height 15 ft 9 in (4.80 m); wing area 350 sq ft (32.84 m²).

Armament: Four 20-mm Mk 12 cannon with 125 rounds per gun plus two or four Sidewinder heat-seeking missiles or up to 5,000 lb (2,268 kg) of external ordnance for close air support missions.



Key to Vought F-8E Crusader

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Sukhoi Su-7 (mid 1955)

The trend initiated by such aircraft as the F-84F Thunderstreak (see pages 188-189) towards a category of fighters optimised for the strike and ground attack missions was taken a stage further in the Soviet Union when, in 1958, the Su-7B entered service. A large comparatively unsophisticated aeroplane powered by a massive turbojet, the Su-7B was the first dedicated ground attack fighter with supersonic capability to achieve service status, and one which was to be manufactured in vast numbers from the late fifties, through the sixties and into the seventies.

Created by the design bureau headed by Pavel O. Sukhoi which flew an aerodynamic prototype as the S-1 mid 1955 the new ground attack fighter embodied several design innovations insofar as Soviet combat aircraft were concerned such as a variable intake shock diffuser, cone and a sub-type all-flying horizontal tail. A second prototype embodying some aerodynamic refinement, the S-2 was productionised as the S-22 and ordered into large-scale production in 1958 as the Su-7B. Progress via development resulted in the Su-7BM, with uprated engine and enhanced systems, and the Su-7BKL which introduced a unique "wheel-skid" (kolo-lyzha) arrangement and a low-pressure nosewheel tyre. This overcame the inability of the aircraft to accept low-pressure mainwheel tyres and afforded a measure of rough field capability. Equivalent tandem two-seat conversion trainer versions were the Su-7U and Su-7UMK, the definitive production single-seat model being the upgraded Su-7BMK.

The use by the Su-7 of a 60 deg swept wing resulted in embarrassingly limited external stores flexibility the radius of action with a worthwhile ordnance load was overly modest and with full afterburning the endurance on internal fuel was limited to barely more than eight minutes. However the Sukhoi ground attack fighter possessed good low level gust resistance, pleasant handling characteristics, and maintenance simplicity and a high standard of reliability under operational conditions.

SPECIFICATION Su-7BMK

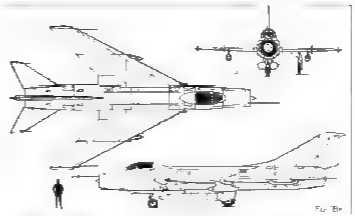
Power Plant: One Lyulka AL-7F-1 turbojet rated at 15 740 lb (7 140 kg) dry thrust and 21,825 lb (9 900 kg) thrust with afterburning. Internal fuel capacity, 910 Imp gal (4 140 l) with provision for two 132 Imp gal (600 l) drop tanks.

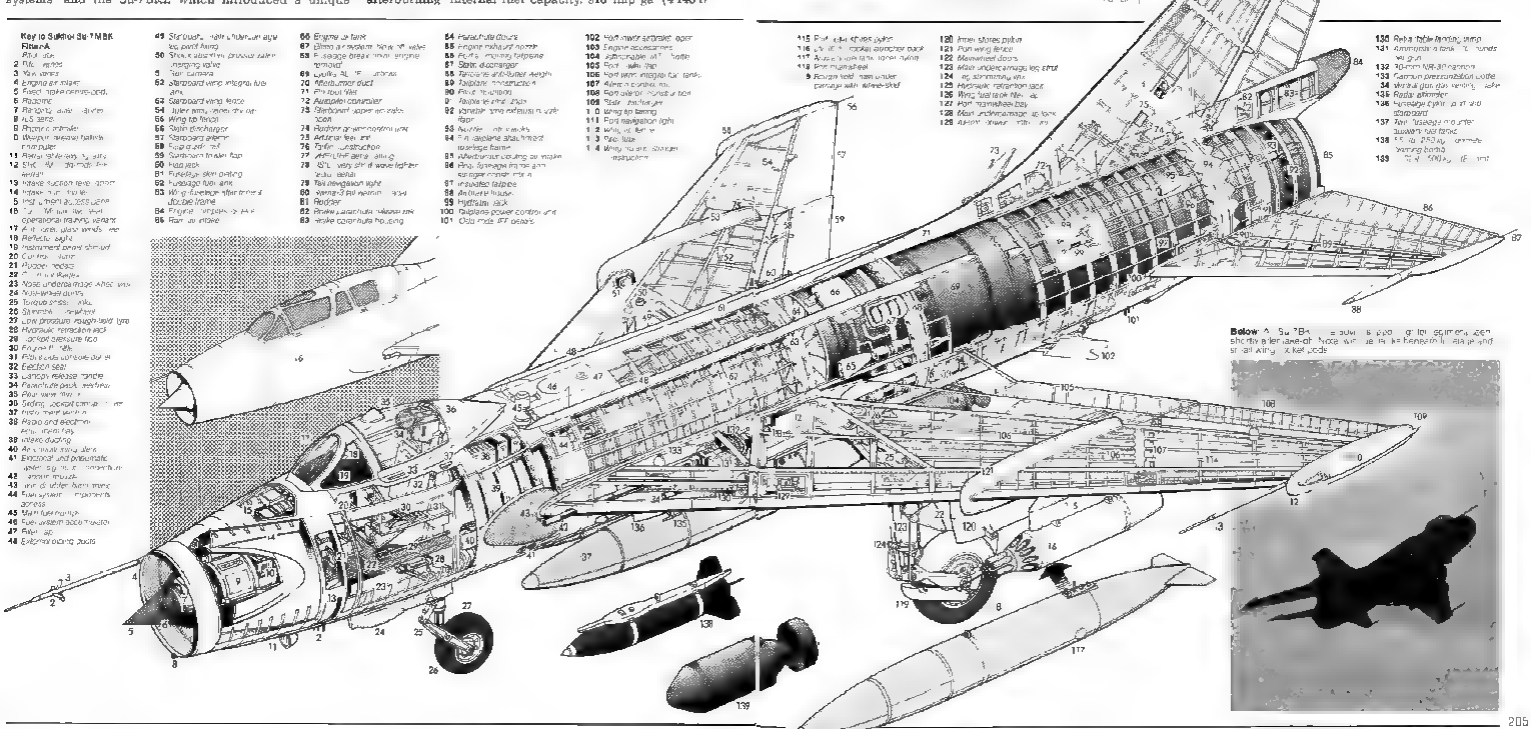
Performance: Max speed without external stores (max dry thrust), 540 mph (870 km/h) or M=0.72 at 1,000 ft (305 m), (max afterburning), 720 mph (1 160 km/h) or M=0.95 at 1,000 ft (305 m), 1 055 mph (1 700 km/h), or M=1.6 at 36,090 ft (11 000 m), (high drag configuration), 790 mph or M=1.2 at 36,090 ft (11 000 m); max climb, 30 000 ft/min (152.4 m/sec); tactical radius (HI-LO-HI profile), 285 mls (460 km); max range, 900 mls (1 450 km).

Weights: Empty equipped, 19,000 lb (8 620 kg); normal loaded, 28,455 lb (12 900 kg); max take-off, 29 750 lb (13 500 kg).

Dimensions: Span, 28 ft 9¾ in (8.77 m); length (including probe), 55 ft 1½ in (16.80 m); height, 15 ft 0 in (4.57 m).

Armament: Two 30-mm Nudelman-Rikhter NR-30 cannon with 70 rpg. Four underwing stores stations for two 1,102 lb (500 kg) and two 1,653 lb (750 kg) bombs or equivalent loads of rocket pods and other ordnance.





Below: A Su-7BM as used by the Polish air force, with short fin and tailplane, nose wheel, and small wing-tip fuel pods.

Republic F-105 Thunderchief (October 1955)

Above F-105D 57-5810 of the 354th Tactical Fighter Squadron, 355th Tactical Fighter Wing, operating from Seymour Johnson AFB, North Carolina, in the late 1960s

Signifying departure from the long-accepted philosophy of designing an interceptor fighter and subsequently adapting it for strike and close air support missions, the Thunderchief was optimised from the outset for the fighter-bomber role, albeit primarily for delivery of an internally housed nuclear store in a HI-LO-LO-HI penetrat on sortie. Circumstances, however, were to dictate its employment with external conventional ordnance and the internal weapons bay occupied by a 325 Imp gal (1 477 l) fuel tank as an all-weather interdictor.

Flown (as the YF-105A) on 22 October 1955 as the largest and heavy est sing e-seat fighter conceived to that time, the Thunderchief first entered USAF service as the F-105B in 1958; the definitive single-seat mode was the F-105D. Production (833 built) was completed in 1964.

SPECIFICATION F-105D-31 Thunderchief

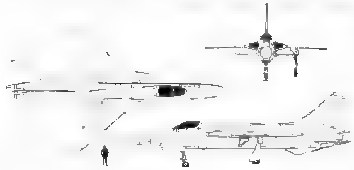
Power Plant One Pratt & Whitney J75-P-19W turbojet rated at 16 100 lb (7 303 kg) dry thrust, 24 500 lb (11 113 kg) with afterburning and 26,500 lb (12 020 kg) for 2 5 min with afterburning and water injection. Internal fuel capacity 996 Imp ga. (4 390 l), plus 325 Imp gal (1 477 l) weapons bay tank and provision for one centre line 541 Imp ga (2 460) or 375 Imp ga. (1 705 l) and two underwing 375 Imp gal (1 705 l) drop tanks

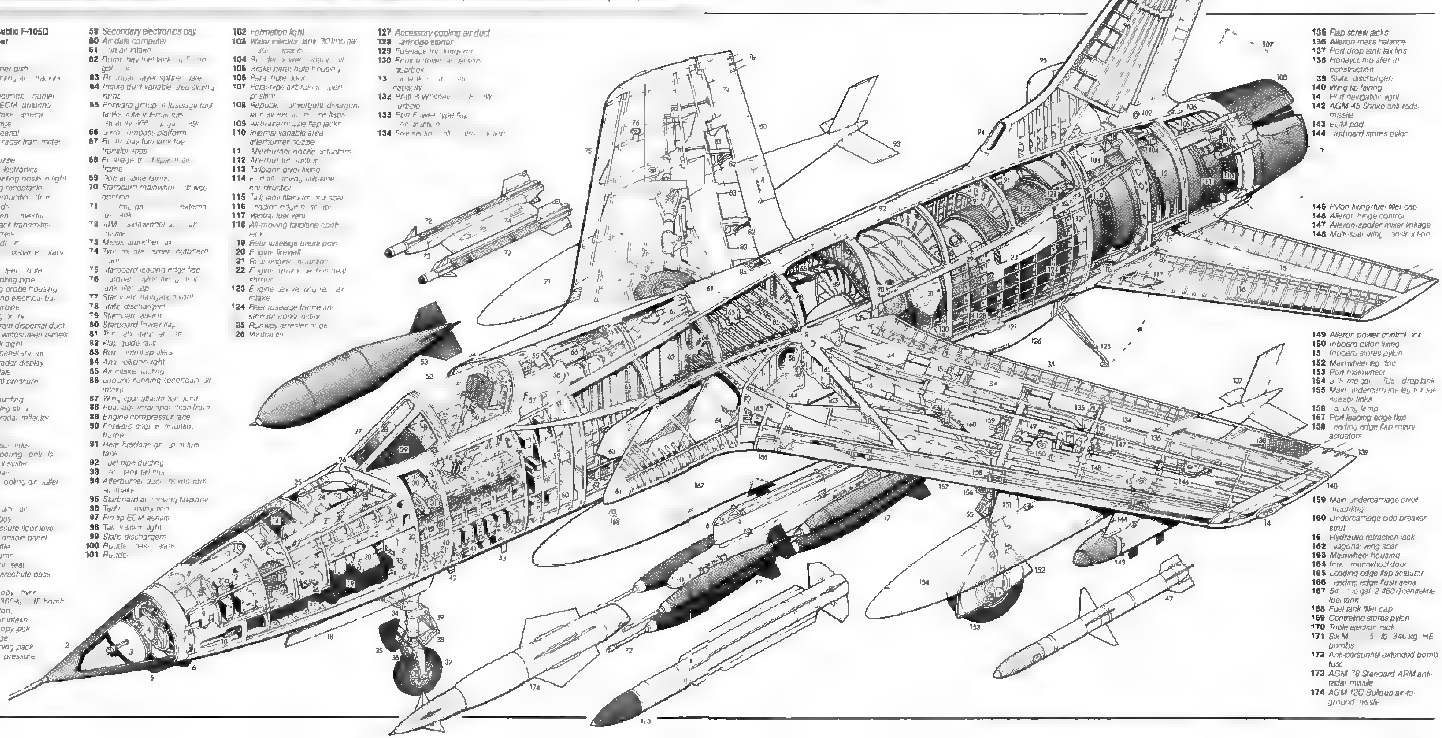
Performance Max speed 836 mph (1 345 km h) or M 1 1 at sea level, 1,372 mph (2 208 km/h) or M 2 08 at 36,090 ft (11 000 m), max initial climb 38 500 ft min (195 58 m sec) combat ceiling, 49,000 ft (15 120 m); combat radius (w ng drop tanks and internal stores) 778 mls (1 252 km) at 584 mph (940 km/h), at 30,000-39,450 ft (9 145-12 025 m); ferry range, 2 207 mls (3 552 km)

Weights Empty 28 855 lb (12 181 kg), normal combat, 35 637 lb (16 165 kg), max 52 838 lb (23 967 kg)

Dimensions Span, 34 ft 10¾ in (10,64 m), length 64 ft 4¾ in (19 63 m), height, 19 ft 8¾ in (6,00 m); wing area 385 sq ft (35,77 m²)

Armament One 20-mm M-61 rotary cannon with 1 028 rounds, and provision for up to 12,000 lb (5 443 kg) of external ordnance (eg 16 x 750-lb 340-kg M 117 bombs)





Key to Republic F-105D Thunderchief

1 Pitot tube
2 Rudder
3 Rudder actuator jack
4 Rudder trim actuator mechanism
5 Forward equipment compartment, ECM antennas
6 Anti-icing spray nozzle
7 Radome hinge
8 ADF sense aerial
9 Fixed radar reflector mounting
10 Gun muzzle
11 Underwing stiffeners
12 Upper strengthening rib, right
13 Air refuelling receptacle
14 Electronic countermeasures equipment
15 Cockpit canopy
16 Angle of attack transmitter
17 Cockpit floor
18 Nose wheel doors
19 Nose wheel retracted position
20 Air refuelling probe housing
21 Engine gun firing port
22 Air refuelling probe housing
23 Alternator and electrical equipment
24 Air driven turbine
25 Air refuelling probe
26 Afterburner tail pipe discharge duct
27 Air driven emergency hydraulic pump
28 Radar attack light
29 Instrument panel shroud
30 Navigation radar display
31 Rudder pedals
32 Underfloor air conditioning ducting
33 Control mounting
34 Nose wheel leg strut
35 Nose wheel retraction actuator
36 Trapeze tube
37 Nose wheel
38 Nose wheel doors
39 Hydraulic retracting cylinder
40 Pitot static system hydraulic actuator
41 Electronics cooling air outlet
42 IFF gong
43 UHF gong
44 Air conditioning equipment bay
45 Cockpit pressure floor level
46 Rudder trim actuator pulley
47 Engine throttle
48 Control column
49 Rudder pedal rod
50 Seat back parachute pack
51 Headrest
52 Cockpit canopy frame
53 Canopy hinge, forward jettisoned position
54 Rear view periscope
55 Cockpit canopy jack
56 Canopy hinge
57 Air conditioning duct
58 Cockpit pressure bulkhead
59 Secondary electronics bay
60 Air data computer
61 Wing root fillet
62 Flight bay fuel tank (1 705 l gal)
63 Fin root fairing
64 Fixed duty transfer jack stowed spring
65 Forward group of fuselage fuel tanks, side view
66 Spring hydraulic platform
67 Air driven fuel pump for hydraulic pump
68 Fuselage longitudinal frame
69 Nose wheel stowed
70 Transport mounting lug
71 Fuel tank
72 UHF antenna
73 Mission transmitter
74 Fin root fairing, stowed position
75 Transport mounting strap
76 Stowed position of fin tip
77 Spring hydraulic actuator
78 Static discharger
79 Spring jack
80 Stowed fuselage
81 Fin root fairing
82 Kick guide
83 Rear mounting lug
84 Rear wheel right
85 Air intake lighting
86 Wing root fairing, centreline stowed
87 Wing root stowed
88 Fuselage longitudinal frame
89 Engine compressor bay
90 Fuselage longitudinal frame
91 Rear fuselage fuel (1 705 l) tank
92 Wing root duct
93 Wing root fairing
94 Afterburner, duct, flame tube outlet
95 Electronics equipment bay
96 Tail mounting
97 Fin to fuselage
98 Tail wheel right
99 Static discharger
100 Rudder hinge
101 Rudder
102 Formation light
103 Wave interface, aerial, 90 mm gun
104 Gun barrel
105 Hydraulic fluid tank
106 Fuel tank
107 Fuselage longitudinal frame
108 Rudder, longitudinal stowed position
109 Hydraulic actuator for gun
110 Internal variable area afterburner nozzle
111 Afterburner nozzle actuator
112 Air duct
113 Tailpipe gas flow
114 Fuel tank, underwing, aft fuselage
115 Tail wheel doors
116 Tailpipe support
117 Vertical tail fin
118 Air driven turbine cooling air
119 Rear wheelbay break point
120 Fuselage frames
121 Rear wheel, retracted
122 Fuselage longitudinal frame
123 Engine air intake, air intake
124 Rear fuselage frame, underwing cross spar
125 Fuselage longitudinal frame
126 Wing root
127 Accessory cooling air duct
128 Jettisoned canopy
129 Fuselage longitudinal frame
130 Fuselage longitudinal frame
131 Fuel tank
132 Wing root, underwing stowed
133 Gun barrel, port side
134 Fuselage longitudinal frame
135 Rear fuselage longitudinal frame
136 Gun barrel
137 Aileron mass balance
138 Fuel drop tank, port side
139 Hydraulic actuator, retracted
140 Wing fuel tank
141 Wing root fairing
142 AGM-45 Shrike air to ground missile
143 Wing root
144 Underwing stores pylon
145 Pylon hanger, port side
146 Aileron hinge control
147 Aileron equalizer motor linkage
148 Main wheel well, port side
149 Aileron power control, port
150 Inboard aileron hinge
151 Inboard stores pylon
152 Main wheel leg, port
153 Port nacelle
154 Fuel tank (1 705 l) drop tank
155 Main undercarriage leg, port side, inboard side
156 Outboard side
157 Port trailing edge flap
158 Trailing edge flap mounting actuator
159 Main undercarriage cover housing
160 Undercarriage side brace strut
161 Hydraulic retraction jack
162 Undercarriage seat
163 Wheelbay housing
164 Inner main wheel door
165 Loading edge flap actuator
166 Leading edge flap arm
167 Six single 2 250-lb (1 000-kg) bombs
168 Fuel tank fin cap
169 Centreline stores pylon
170 Trailing edge flap
171 Six M 117 750 lb 340 kg HE bombs
172 Air-launched underwing bomb fuze
173 AGM-78 Standard ARM anti-radar missile
174 AGM-12D Bullpup air-to-ground missile

Saab 35 Draken (October 1955)

Characterised by outstanding aerodynamic individuality its double-delta configuration being unique at inception and remaining so to this day, the J 35 Draken (Dragon) designed under the leadership of Erik Bratt was created to fulfil a specification almost as individualistic as the fighter in which it was to fly. Formulated in 1949 it called for high supersonic speed, climb and altitude capabilities for the intercept mission combining these attributes with exacting low-speed handling and field performance requirements to satisfy the needs of a newly-emerging Swedish quick-reaction and dispersal philosophy embracing operation from stretches of specially prepared roadway.

The double-delta geometry arose from efforts to endow a dimensionally small airframe with the greatest possible volume, the sharply swept inner delta (80 deg) permitting sufficient depth to accommodate all fuel and the main undercarriage members, yet in combination with the moderately swept (57 deg) outer delta, offering both favourable transonic and supersonic drag characteristics and the loadings and lift necessary for the specified low speed and field performance. Furthermore it offered a more conventional relationship between centres of gravity and pressure than a normal delta wing.

The first Draken prototype was flown on 25 October 1955. The initial production model, the J 35A, entering service with Flygvapnet from March 1960. The J 35A (90 built), equipped for conventional head pursuit attack, gave place to the J 35B (89 built) equipped for collision course attack, while the J 35D (92 built) and its tactical reconnaissance equivalent, the S 35E (60 built) replaced the RM 6B (Avon 200 Srs, turbojet with the uprated RM 6C (Avon 300 Srs). The definitive model, the J 35F (208 built), which began to enter service in 1965, featured a more potent missile armament and generally more sophisticated systems. Export versions of the J 35F were supplied to Denmark (40 together with 11 two-seater trainers, and Finland (15 ex Swedish, where 12 were licence assembled (J 35S.

SPECIFICATION: Saab 35F-2 Draken

Power Plant: One Volvo Flygmotor (Rolls-Royce) RM 6C (RB 146 Avon Mk 80) turbojet rated at 12 790 lb (5 800 kg) dry thrust and 17,635 lb (8 000 kg) with afterburning. Internal capacity, 875 Imp gal (3 980 l); provision for two 280 Imp gal (1 275 l) and two 110 Imp gal (500 l) drop tanks.

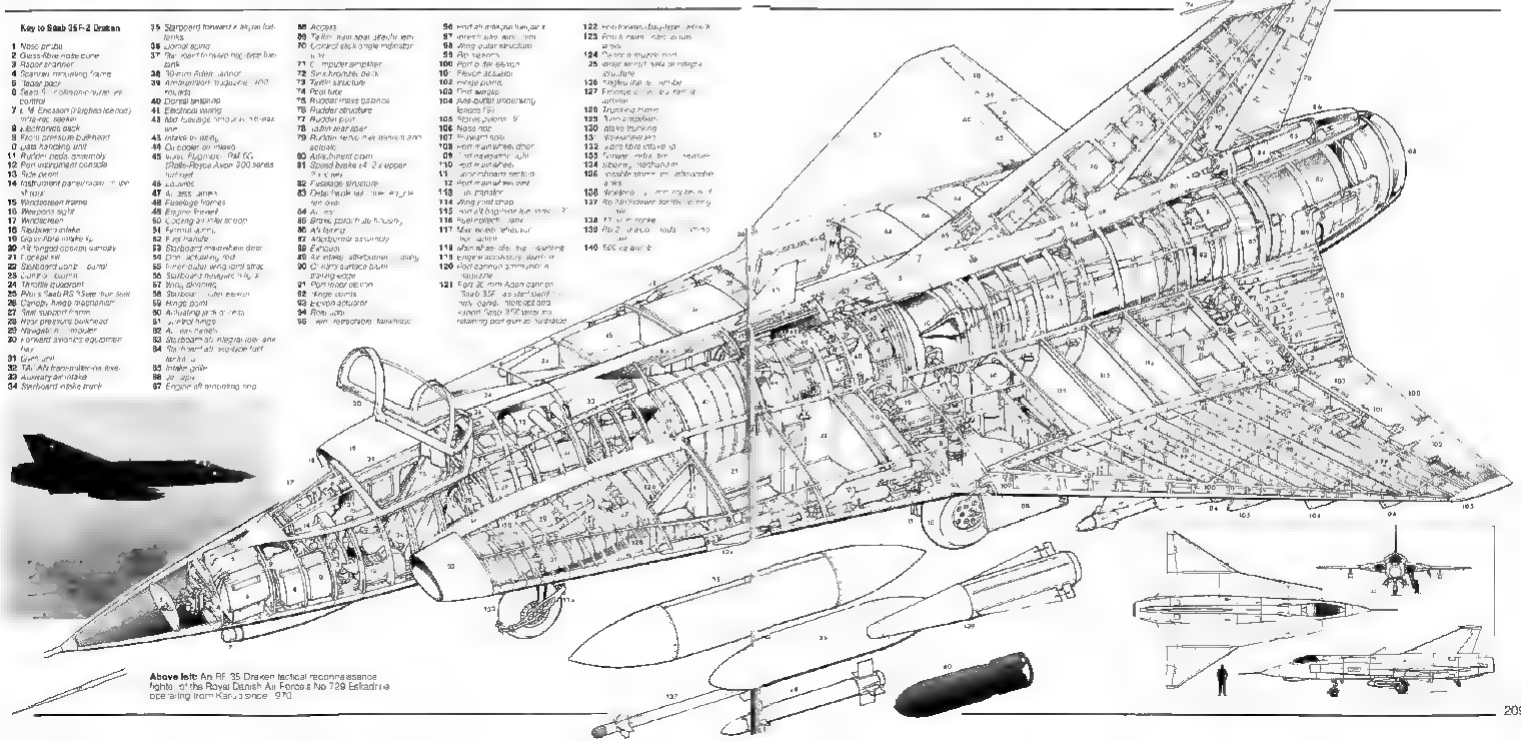
Performance: Max speed 1 320 mph (2 124 km/h) or M=2.0 at 36,090 ft (11 000 m), (with two Rb 27 and two Rb 28 AAMs) 824 mph (1 487 km/h) or M 1.4, initial climb 34,450 ft/min (175 m/sec); time to 36,090 ft (11 000 m) 2.6 min, to 49,210 ft (15 000 m) 5.0 min, combat radius (internal fuel and HI-LO-HI mission profile) 395 mls (635 km), (with two 280 Imp gal 1 275 l drop tanks and two 1,000-lb 453.6 kg bombs) 623 mls (1 003 km), ferry range, 2,020 mls (3 250 km).

Weights: Empty, 17 339 lb (7 865 kg), normal combat 25,132 lb (11 400 kg), max. 35,273 lb (16 000 kg).

Dimensions: Span 30 ft 10 in (9.40 m), length (including pitot) 50 ft 4 in (15.35 m), height 12 ft 9 in (3.88 m), wing area 529.6 sq ft (49.20 m²).

Armament: One 30-mm Aden M 55 cannon with 100 rounds and (intercept mission) two radar-guided Rb 27 and two IR-guided Rb 28 (Falcon) missiles, or two or four Rb 24 (Sidewinder) missiles, or (attack mission) up to 9,000 lb (4 082 kg) of ordnance.

Above: A J 35F Draken in flight. Strapped to Nord Rb 02 and Rb 28 Falcons are seen respectively, inboard and outboard.



Key to Saab 35 F-2 Draken

1 Nose probe
2 Glass-fibre radome
3 Radar dish
4 Scanner mounting frame
5 Radar pack
6 Search/IFF antenna
7 L-M Ericsson (Raytheon licence) ranging scanner
8 Electronics pack
9 Pitot pressure pulsemeter
10 Cockpit heating unit
11 Rudder pedal assembly
12 Port instrument console
13 Side panel
14 Instrument panel (radar/IFF display)
15 Windscreen frame
16 Weapons sight
17 Windscreen
18 Sideways strike
19 Glass-fibre intake lip
20 Hinged access assembly
21 Cockpit lift
22 Starboard undercarriage door
23 Cockpit floor
24 Throttle quadrant
25 Pilot's Saab RS 3 Seer ejection seat
26 Canopy hinge mechanism
27 Seat support frame
28 Main pressure bulkhead
29 Navigation computer
30 Forward avionics equipment bay
31 Gun port
32 Tail/Air transmitter-receiver
33 Auxiliary air intake
34 Starboard vehicle trunk
35 Starboard forward wing/tail fuel tanks
36 Lamp aging
37 Tail/Air transmitter-receiver fin tank
38 Nomin Aden cannon
39 Ammunition trays (100 rounds)
40 Dorsal longeron
41 Electrical wiring
42 Main fuselage longeron
43 Intake trimming
44 Cockpit air intake
45 Main flight control (RM 6C (Rolls-Royce Avon 300 series turbojet)
46 Louvres
47 Air bleed ducts
48 Fuselage frames
49 Engine thrust
50 Cooling air intake duct
51 Fairing panel
52 Fuel handle
53 Starboard main undercarriage door
54 Drop tank/fuel feed
55 Inner delta wing (and strake)
56 Starboard hydraulic fluid
57 Wing dihedral
58 Starboard aileron
59 Hinge point
60 Actuating jack (ailerons)
61 Aileron hinge
62 Aileron frames
63 Starboard air integral fuel tank
64 Starboard wing/fuselage fairing
65 Intake grille
66 Air ducts
67 Engine lift mounting ring
68 Access
69 Main fuel tank
70 Control stick angle indicator
71 Computer amplifier
72 Sideways strike
73 Tail structure
74 Rear fuel
75 Rudder mass balance
76 Rudder structure
77 Rudder post
78 Main rear spar
79 Rudder hydraulic actuation jack
80 Afterburner cone
81 Speed brake (4 2 upper 4 2 lower)
82 Fuselage structure
83 Delta/tail fin rear spar
84 Air ducts
85 Brake parachute housing
86 Air bottle
87 Afterburner assembly
88 Fairing
89 Air intake afterburner assembly
90 Control surface blow boundary edge
91 Spring balancing
92 Starboard aileron
93 Hinge points
94 Actuating jack (ailerons)
95 Aileron hinge
96 Aileron frames
97 Starboard air integral fuel tank
98 Starboard wing/fuselage fairing
99 Wing root
100 Port main undercarriage door
101 Wing outer structure
102 Hinge points
103 Port aileron
104 Aileron balance/balancing tanks (5)
105 Trim actuators
106 Nose rib
107 Rear spar
108 Port main wheel door
109 Port hydraulic jack
110 Port wheel well
111 Wing/fuselage fairing
112 Port main wheel
113 Air regulator
114 Wing root strake
115 Port air bleed/air bleed duct
116 Fuel probe
117 Main wheel (Dunlop)
118 Wheel arch side fairing
119 Engine accessory drive
120 Port cannon compartment
121 Port 30 mm Aden cannon (Saab 35F as standard with Oerlikon 30 mm cannon) Port Saab 35E prototype retaining port gun as ballast
122 Hydraulic/pneumatic pipework
123 Rear fuselage fuel tanks
124 Control equipment
125 Wing/tail/fuselage structure
126 Tailplane actuator
127 Fairing panel
128 Tailplane frame
129 Tailplane
130 Brake parachute
131 Wheel/brake
132 Port fuel tank
133 Fairing/intake duct
134 Starting/ignition
135 Double slotted jet afterburner
136 Tailplane
137 Rear fuselage fairing
138 Fin root fairing
139 Rb 27 (Falcon) missile
140 Rear wheel

Mikoyan-Gurevich MiG-21 (June 1956)

One of the generation of bi-sonic fighters following in the wake of the Korean conflict, the MiG-21 for long the subject of contention in the West, was, by the standards of its day, an outstanding warplane but for certain fundamental shortcomings. It would have been a lightweight fighter par excellence. As it was it possessed a better transonic capability, a smaller turning circle and markedly superior airfield performance than either of its western contemporaries, the Mirage and Starfighter.

The MiG-21 was, by any standard, a classic design and exerted a profound influence on western fighter design thinking. Conceived as an unsophisticated day fighter as which it entered service in 1959, it had evolved by means of a complex genealogical process, as a limited all-weather dual role fighter by the early seventies, retaining no more than a configurational similarity to the initial model. By the beginning of the eighties, it was finally outclassed in such vital dogfighting attributes as turn rate and radii, acceleration and sustained climb yet although advanced in conceptual age, it remained in production (albeit for export) in 1981, by which time more than 6,000 had been manufactured.

The aerodynamic prototype of the MiG-21 the Ye-4 with an RD-9 engine, flew on 14 June 1956 being re-engined a year later with the more powerful R-11 as the Ye-5. Still further refined in 1958 as the Ye-6 with an R-11F 300 engine it was productionised in the following year as the Ye-6T entering large-scale production as the MiG-21F. What was to be a somewhat convoluted evolution of the basic design began in 1960, with the debut of the limited all-weather Ye-7 which was to be built in large numbers as the MiG-21PF and, subsequently, with flap-blowing (as the MiG-21PFS) and various equipment, armament and systems changes (as the MiG-21PFM and PFMA.

The lighter R-13 turbojet affording 30 per cent greater dry thrust resulted in a second generation (MiG-21MF and SMT) at the beginning of the seventies which, in turn, gave place to the "third generation" MiG-21Mbis with an R-25 engine providing 13·6 per cent more afterburner power mated with upgraded avionics and improved structural standards.

The basic characteristics of the MiG-21 have remained virtually constant throughout. By the standards of its generation it is highly agile, but high turn rates are accompanied by steep drag rise and its radius of action is over modest.

SPECIFICATION: MiG-21MF

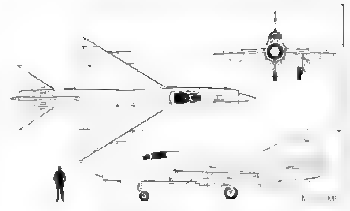
Power Plant: One Tumansky R-13-300 turbojet rated at 11,244 lb (5,100 kg) thrust dry and 14,550 lb (6,600 kg) thrust with afterburning. Internal fuel capacity 572 Imp gal (2,600 l) and provision for three 108 Imp gal (490 l) drop tanks.

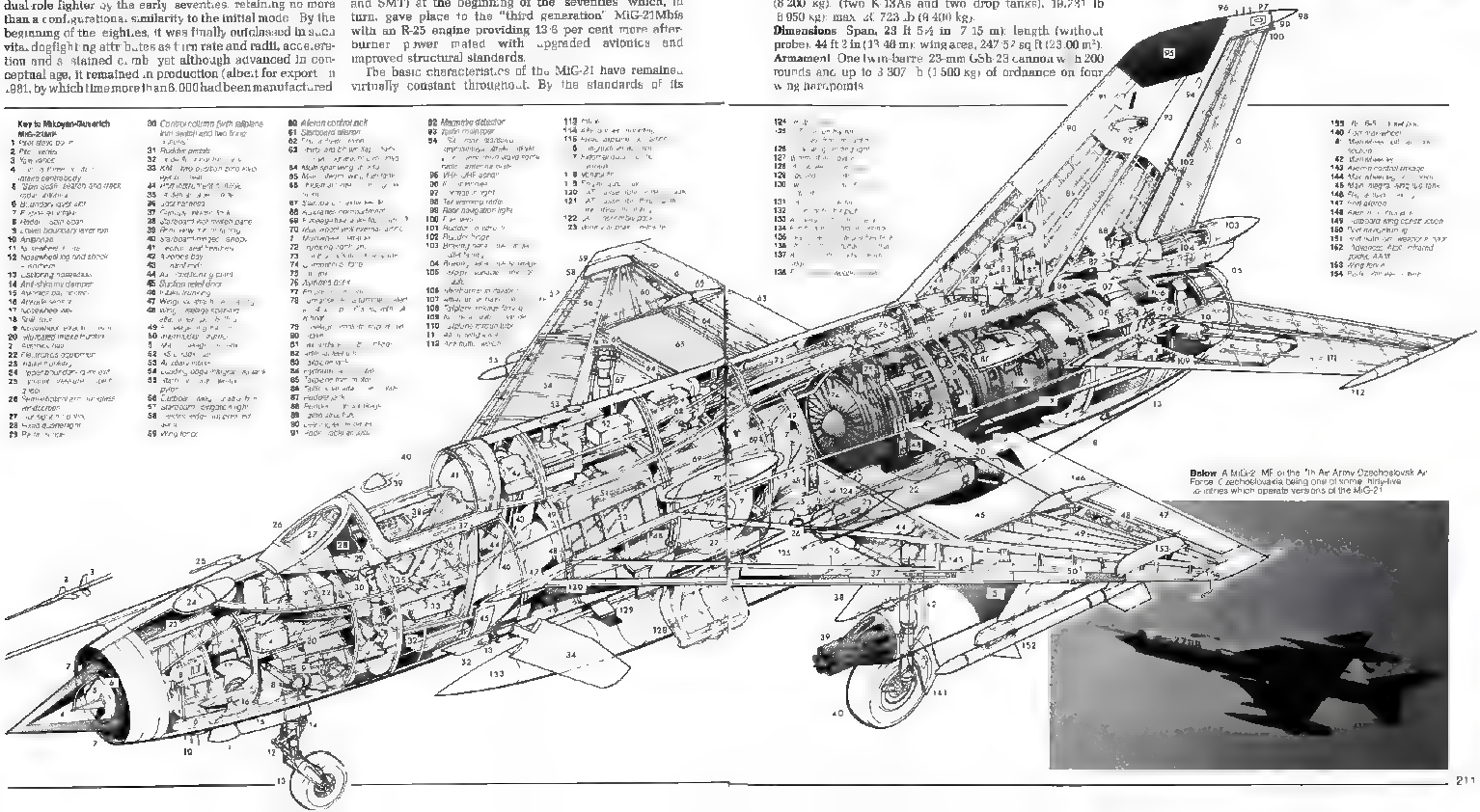
Performance: Max speed (clean) 808 mph (1,300 km h) or M 1·06 at 1,000 ft (305 m), 1,988 mph (3,230 km h) or M 2·1 above 36,090 ft (11,000 m), max range (internal fuel) 683 mls (1,100 km), (max external fuel) 1,118 mls (1,800 km).

Weights: Normal loaded (with four K-13A AAMs), 18,078 lb (8,200 kg), (two K-13As and two drop tanks), 19,731 lb (8,950 kg); max, 21,723 lb (9,400 kg).

Dimensions: Span, 23 ft 5½ in (7·15 m); length (without probe), 44 ft 2 in (13·46 m); wing area, 247·57 sq ft (23·00 m²).

Armament: One twin-barrel 23-mm GSh-23 cannon with 200 rounds and up to 3,307 lb (1,500 kg) of ordnance on four wing hardpoints.





Key to Mikoyan-Gurevich MiG-21MF

1 Pitot boom
2 Pitot tubes
3 Yaw vanes
4 Air intake for air data sensors and control
5 Starboard section and deck control switches
6 Boundary layer slot
7 Forward canopy
8 Hood boundary layer fence
9 Cockpit boundary layer fence
10 Windscreen
11 Windscreen rain
12 Windscreen rain and shock wiper
13 Leading edge
14 Anti-shock diamond
15 Windscreen
16 Armour screen
17 Windscreen
18 Seat rail
19 Windscreen
20 Windscreen
21 Control rod
22 Electronics equipment
23 Rudder hydraulic
24 Rudder actuator
25 Rudder actuator
26 Control column fitted with rudder
27 Rudder
28 Rudder
29 Rudder
30 Control column fitted with aileron and two firing buttons
31 Rudder pedals
32 Rudder
33 Kill switch
34 Port aileron
35 Port aileron
36 Port aileron
37 Control rod
38 Starboard aileron
39 Port aileron
40 Port aileron
41 Port aileron
42 Aileron
43 Aileron
44 Aileron
45 Starboard aileron
46 Aileron
47 Wing
48 Wing
49 Wing
50 Wing
51 Wing
52 Wing
53 Aileron
54 Leading edge
55 Starboard
56 Carbon
57 Starboard
58 Starboard
59 Wing root
60 Aileron control jack
61 Starboard aileron
62 Port aileron
63 Port and starboard
64 Main spar
65 Main
66 Port
67 Starboard
68 Port
69 Port
70 Port
71 Port
72 Port
73 Port
74 Port
75 Port
76 Port
77 Port
78 Wing
79 Wing
80 Wing
81 Wing
82 Wing
83 Port
84 Port
85 Port
86 Port
87 Port
88 Port
89 Port
90 Port
91 Port
92 Magnetic detector
93 Rudder main jack
94 Port
95 Port
96 Port
97 Port
98 Tail warning radio
99 Rear navigation light
100 Fin
101 Rudder
102 Rudder hinge
103 Braking
104 Braking
105 Braking
106 Port
107 Port
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154 Port

Below: A MiG-21MF of the 7th Air Army Czechoslovak Air Force (Czechoslovakia being one of nine Warsaw Pact countries which operate versions of the MiG-21)

Dassault-Breguet Mirage III (November 1956)

Above: A Mirage 5V of the Escadrille de Chasse 36 of the Venezuelan Air Force. The Mirage 5 has a similar airframe to the Mirage IIIE

From the late 1950s, many fighter designers were attracted to the simple tailless delta configuration offering low wave drag with excellent fuel volume and permitting traditional constructional methods. Few were to persist with the formula, however, for pure delta geometry invoked certain penalties. Having no horizontal tail, it could not be fitted with trailing-edge flaps and, in consequence, presented high approach speeds and poor landing performance. Its low aspect ratio resulted in high induced drag, penalising sustained turn and manoeuvrability, suffered further as a result of excessive trim drag.

Avions Marcel Dassault was one of only two manufacturers to retain interest in the tailless delta, and its Mirage III, first flown on 17 November 1956, was essentially an extrapolation of the MD 550 Mirage I lightweight mixed-power target-defence interceptor, but linearly some 20 per cent larger and about 30 per cent heavier. Intended primarily as a bomber interceptor, the restricted agility inherent in its configuration was of only limited significance, and the first series production model, the Mirage IIIC, flew on 9 October 1960.

From this basic interceptor, an entire family of fundamentally similar aircraft was to evolve, commencing in 1961 with the dual-role Mirage IIIE and its recce equivalent, the IIIR, continuing in 1967 with the structurally similar but simpler Mirage 5, and reaching its apex in May 1979 with the more powerful Mirage 50. Production of all versions exceeds 1,400 and is expected to continue into 1983.

SPECIFICATION Mirage IIIE

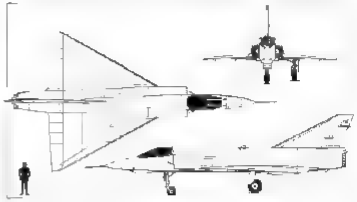
Power Plant: One SNECMA Atar 9C turbojet rated at 9,436 lb (4,280 kg) dry thrust and 13,230 lb (6,000 kg) with afterburning. Internal fuel capacity, 733 Imp gal (3,330 l) with provision for two 137 Imp gal (625 l), 242 Imp gal (1,100 l), 285 Imp gal (1,300 l) or 374 Imp gal (1,700 l) drop tanks.

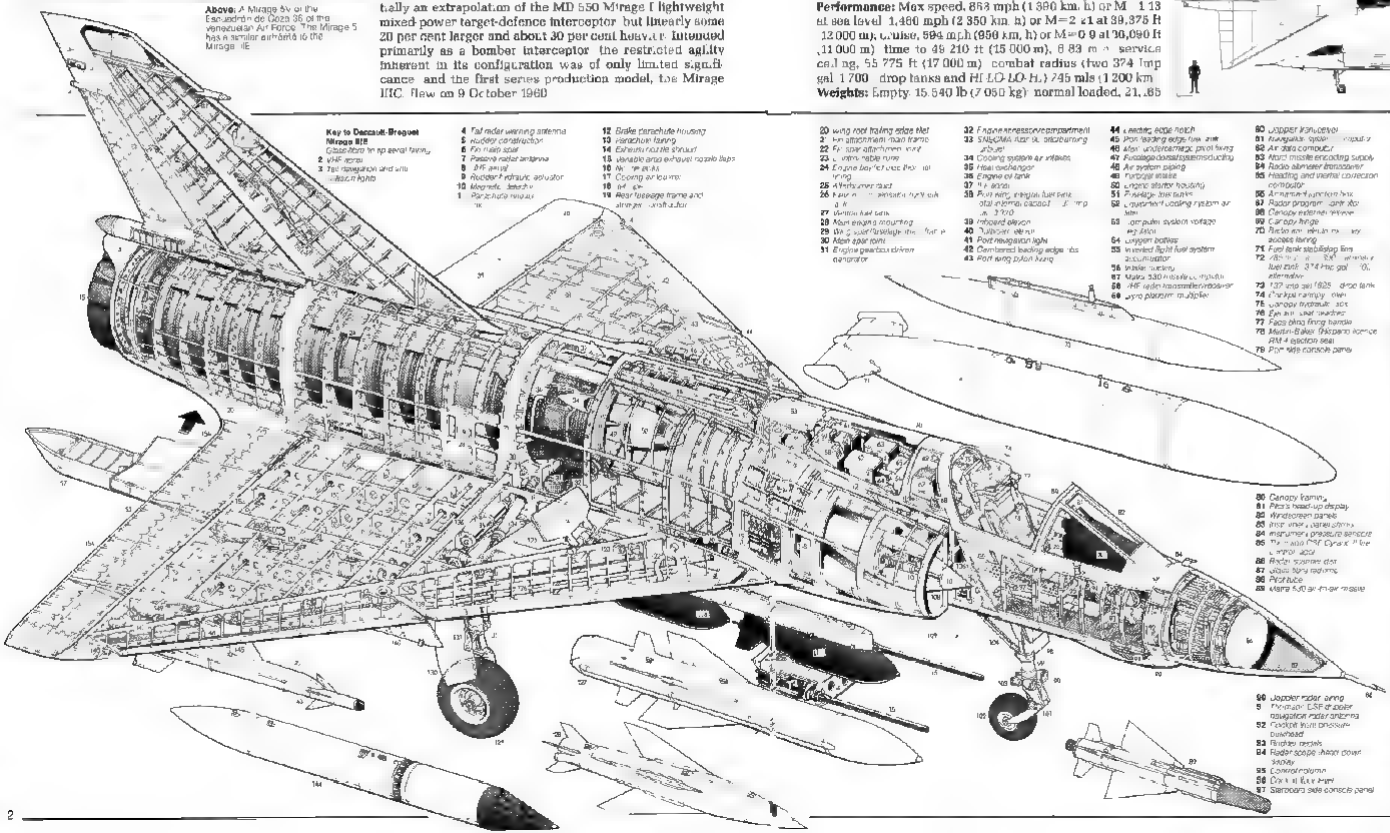
Performance: Max speed, 863 mph (1,390 km/h) or M=1.13 at sea level, 1,490 mph (2,350 km/h) or M=2.21 at 39,375 ft (12,000 m); cruise, 594 mph (956 km/h) or M=0.9 at 36,090 ft (11,000 m); time to 49,210 ft (15,000 m), 6.83 min; service ceiling, 55,775 ft (17,000 m); combat radius (two 374 Imp gal 1,700 l drop tanks and HI-LO-LO-HI) 745 mls (1,200 km).

Weights: Empty, 15,540 lb (7,050 kg); normal loaded, 21,165 lb (9,600 kg); max, 30,200 lb (13,700 kg).

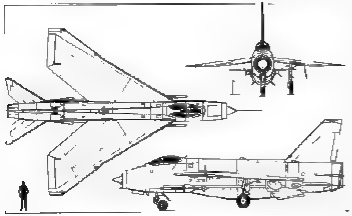
Dimensions: Span, 26 ft 11½ in (8.22 m); length (including pitot), 49 ft 3½ in (15.03 m); height, 14 ft 9 in (4.50 m); wing area, 375 sq ft (34.85 m²).

Armament: Two 30-mm DEFA cannon with 125 rpg and provision for up to 4,000 lb (1,814 kg) of external ordnance.





BAC Lightning (April 1957)



A highly novel approach to the problem of minimising the drag of a dual engine installation and one that was to remain unique was proffered by W.E.W. Petter in designing the Lightning interceptor. Minimal frontal area was achieved by staggering the two turbojets vertically effectively tucking them behind the cockpit and feeding them by means of a complex centre body external compression intake in the nose. Drag was further minimised by adoption of the maximum feasible sweepback of 60 deg at the leading edge which, revealed only by the somewhat earlier Sa-7 (see pages 204-205), permitted a relatively deep wing with useful fuel volume. An unusual feature of this wing was the alignment of the wing-tips with the longitudinal axis which placed the ailerons on the torsional axis of the wing.

The first prototype Lightning, the P.1.B., was flown on 4 April 1957, deliveries of the initial production version the F Mk 1, commencing in June 1960. Developed specifically as a home defence interceptor the formula produced an aeroplane strictly limited in operational flexibility, the initial vices on having a combat radius of only some 150 miles (240 km), but the Lightning offered superb handling, outstanding rates of climb and acceleration, and was one of the very few fighters capable of supersonic flight without recourse to afterburning.

Progressively developed the Lightning remained in production until September 1972, 332 being built.

SPECIFICATION: Lightning F Mk 6

Power Plant: Two Rolls-Royce Avon 301 turbojets each rated at 11 100 lb (5 035 kg) dry thrust, 16,300 lb (7,394 kg) with afterburning. Internal capacity 795 Imp gal (3 341 l), provision for non-jettisonable 535 Imp gal (2 432 l), ventral and (ferry) two 260 Imp gal (1 182 l) overwing tanks.

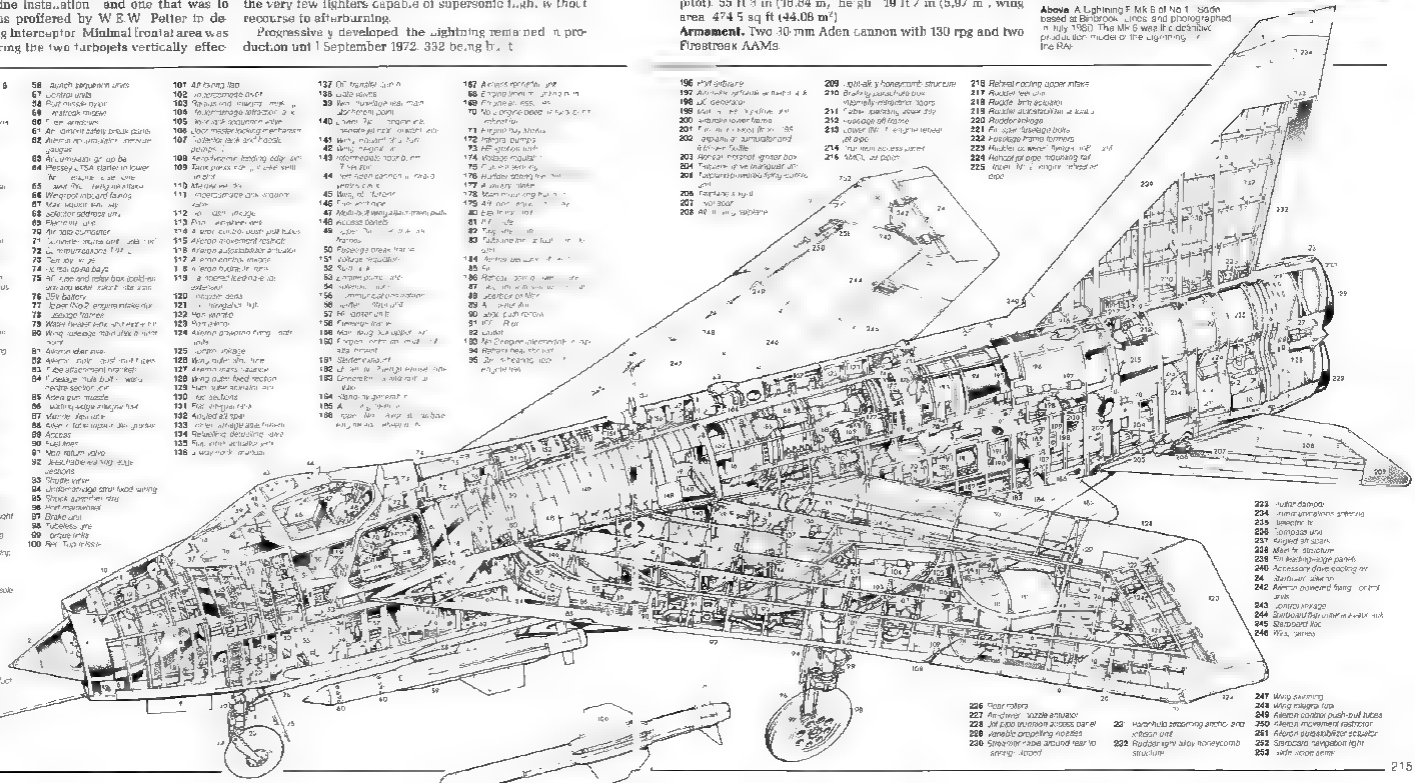
Performance: Max speed 608 mph (1 000 km/h) or M = 1.06 at sea level, 1 386 mph (2 230 km/h) or M = 2.1 at 36 000 ft (10 975 m), initial climb 50,000 ft/min (254 m/sec), time to 65,000 ft (19 810 m) and M = 2.0 5.0 min, max altitude 77,000 ft (23 470 m), max sustained altitude, 57,000 ft (17 375 m), combat radius with ventral fuel pack (Hi-LO) 489 mls (787 km), max combat radius, 604 mls (972 km), ferry range, 1 554 mls (2 500 km).

Weights: Empty 25,820 lb (11 712 kg), combat loaded, 39,840 lb (18 117 kg), max, 41,700 lb (18 915 kg).

Dimensions: Span 34 ft 10 in (10,61 m), length (including pitot), 55 ft 3 in (16,84 m), height 19 ft 7 in (5,97 m), wing area 474.5 sq ft (44.08 m²).

Armament: Two 30-mm Aden cannon with 130 rpg and two Firestreak AAMs.

Above: A Lightning F Mk 6 of No 1 Squadron based at Binbrook, Lincs, and photographed in July 1980. The Mk 6 was the definitive production model of the Lightning for the RAF.



Key to BAC Lightning F Mk 6

1 Pitot head
2 Inflight refuelling probe (port only)
3 Fin-root Airmaster radar antenna housing
4 Engine air intake duct
5 Nose cone
6 Bullet lower speaker
7 Nose camera
8 Nose cone
9 Bullet upper speaker (electronic radio)
10 Firewall, equipment bay
11 Forward fuselage
12 Fuselage frame
13 Cockpit floor
14 Light fighter sight control unit
15 Up-and-down mirror unit
16 Radar ground-working range coupling
17 Nosewheel steering mechanism (port side of nosewheel bay)
18 Nosewheel bay
19 Nosewheel leg
20 Nosewheel strut
21 Rear gear leg
22 Nosewheel retracting mechanism
23 Cockpit floor support
24 Nosing damper and centring cam
25 Air force (port side only)
26 Flight refuelling probe (starboard side)
27 Nosewheel door (port)
28 Rear wheel
29 Nosewheel hydraulic jack
30 Intake boding
31 Cockpit canted 5 deg
32 Pilot's seat
33 Control column
34 Instrument panel (port side only)
35 Rudder pedal assembly
36 Canopy forward frame
37 Rear observer duct
38 Windscreen Electro-form
39 Left nacelle unit (Starboard)
40 Avon engine (port side shown)
41 Starboard engine (port side shown)
42 Canopy top panel de-misting duct
43 Magnesium longeron (port side only shown)
44 Rear bulkhead
45 Fire warning air lines
46 Starboard airframe (port side)
47 Equipment bay (port side) (wing shown)
48 Air-conditioning duct
49 Rear pressure bulkhead
50 Martin Baker ejector seat
51 Port side engine bay
52 Ventral fuel tank attachment
53 Cockpit air duct
54 Wing No 1 engine (port side) (port side)
55 Firestreak weapon (port side)
56 Dutch equipment (port)
57 Control shaft
58 Port nacelle (port)
59 Anti-flash mesh
60 Fin root
61 Fin root (port)
62 Air control safety break (port)
63 Airmaster (port side) (port side)
64 Pressure gauge
65 Air unit (port side)
66 Wing root (port side)
67 Wing root (port side)
68 Wing root (port side)
69 Wing root (port side)
70 Wing root (port side)
71 Wing root (port side)
72 Wing root (port side)
73 Wing root (port side)
74 Wing root (port side)
75 Air intake (port side)
76 Wing root (port side)
77 Wing root (port side)
78 Wing root (port side)
79 Wing root (port side)
80 Wing root (port side)
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82 Wing root (port side)
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99 Wing root (port side)
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107 Air control (port)
108 Wing root (port side)
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McDonnell Douglas F-4 Phantom II (May 1958)

Above:

Unquestionably the most significant and successful jet fighter of the sixties in the western hemisphere, the Phantom I was to claim ubiquity in its conception solely as a shipboard warplane yet far wider usage as a non-naval shore-based multi-role fighter. Characterised by upward canted outer wing panels and downward canted tailplane features adopted to obtain directional stability, the Phantom II first flew as the YF4H-1 on 27 May 1958, entering US Navy service (F4H-1F) late in 1960.

The US Navy was to receive 1,218 Phantoms (the USMC receiving a further 361, deliveries terminating in December 1965. The Phantom II had meanwhile been adopted by the USAF with which it entered service in 1963, a total of 2,640 being procured. Eight countries were to adopt standard USAF models, and special versions were to be produced for the RAF and the Luftwaffe, a total of 5,211 Phantom IIs being built, 138 of them in Japan, the last in May 1981.

SPECIFICATION: F-4E Phantom II

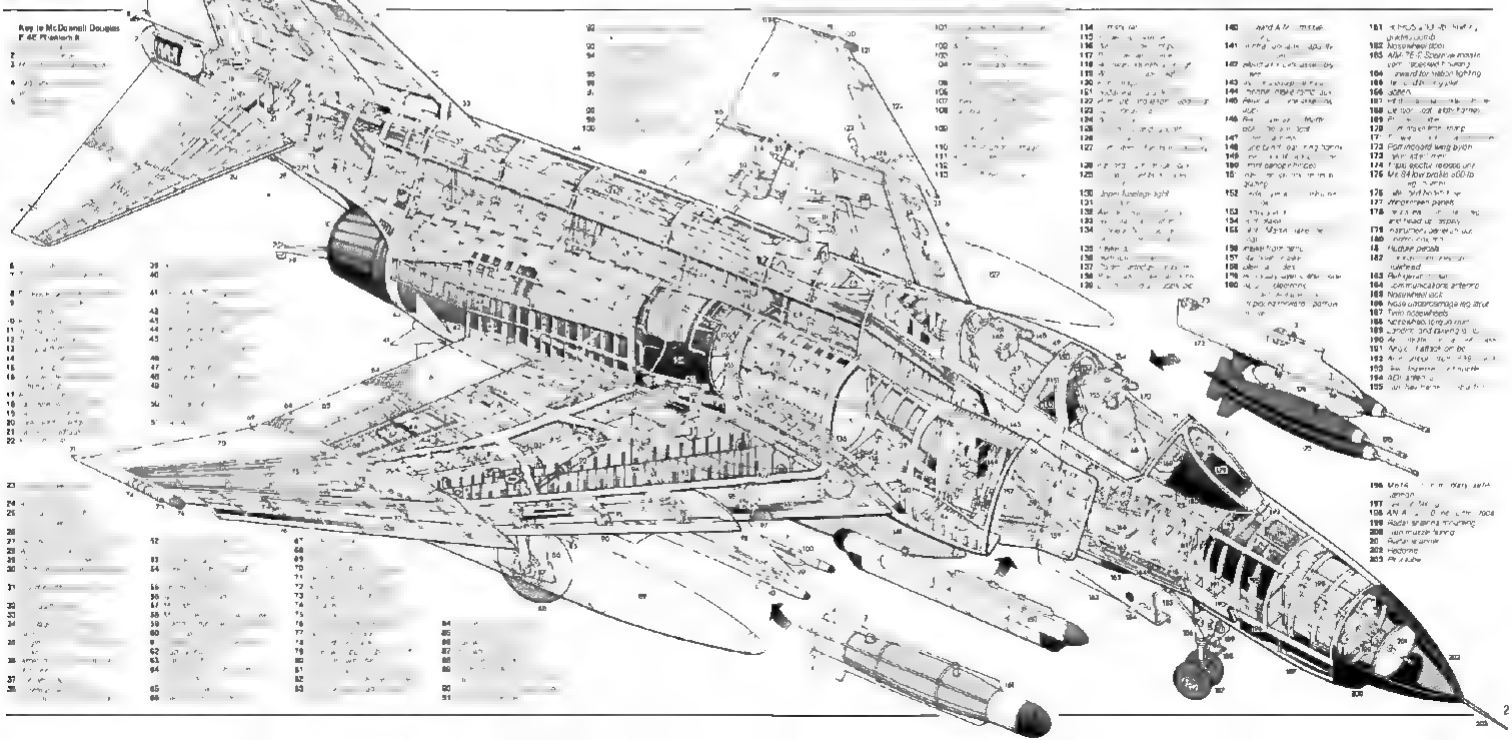
Power Plant: Two General Electric J79-GE-17 turbojets each rated at 11,110 lb (5,040 kg) dry thrust, and 17,900 lb 8,120 kg) with afterburning. Internal fuel capacity: 1,545 Imp gal (7,022 l) and up to 1,116 Imp gal (5,073 l) in three drop tanks.

Performance: Max speed: 1,006 mph (1,619 km/h) or M=1.32 at sea level, 1,484 mph (2,307 km/h) or M=2.17 at 40,000 ft (12,190 m). Initial climb: 49,800 ft/min (253 m/sec); service ceiling: 58,400 ft (17,800 m); combat radius (HI-LO-HI mission profile with 2,000 lb 907 kg store and four AIM-7E AAMs): 473 mls (660 km) at average speed of 583 mph (938 km/h) at 32,550-39,400 ft (10,045-12,010 m); ferry range with one 600 Imp gal (2,273 l) and two 308 Imp gal (1,400 l) drop tanks: 1,613 mls (2,598 km).

Weights: Empty: 30,328 lb (13,757 kg); combat: 41,487 lb (18,818 kg); max: 61,795 lb (28,030 kg).

Dimensions: Span: 38 ft 4 in (11.68 m); length: 63 ft 0 in (19.20 m); height: 16 ft 5 in (5.05 m); wing area: 530 sq ft (49.24 m²).

Armament: One 20-mm General Electric M61A1 multi-barrel rotary cannon and (intercept mission) four AIM-7E-2 Sparrow AAMs, or up to 16,000 lb (7,258 kg) of external ordnance in various combinations.



Northrop F-5 (July 1959)

Above: [illegible] provide dissimilar combat training

From the late forties through the fifties the term *fighter* became ever more a term of expedience in the traditional sense, as a warplane category it had undergone gradual metamorphosis. Its repertoire had expanded from interception and air superiority to take in close air support, interdiction and reconnaissance: the clear-weather diurnal aeroplane had taken on round-the-clock all-weather facilities. Increasing range and payload demands had paralleled this growing sophistication and the upward size-weight complexity vicious spiral was accelerating.

This rising helix was viewed with consternation by many, and several attempts were to be made at least to arrest if not reverse the trend to translate the traditional fighter into modern terms and evolve by the standards of the day, a relatively simple comparatively low cost clear weather fighter. The most successful of these attempts was to be the F-5 designed by Welko Gasich. Conceived as a pure air superiority fighter the first prototype was flown on 30 July 1959 from Palmdale. The F-5 was selected for the counterair role for MAP supply to favoured nations dictating a switch in emphasis from air-air to air-ground capability.

Designated F-5A in single-seat and F-5B in two-seat forms, the fighter attained service early in 1965, 1,044 being produced, including 220 in Canada (as CF-5 and NF-5) and 89 in Spain (as SF-5). In 1970, an upgraded second-generation version, the F-5E Tiger II was selected to fulfil the new International Fighter Aircraft (IFA) requirement, a variant being optimised for the air superiority mission. The F-5E flew on 11 August 1972 and, with its two-seat equivalent, the F-5F more than 1,000 had been delivered to 18 customers by the end of 1981 when a third general development, the F-5G Tigershark was under construction.

The F-5G, scheduled to fly September 1982, will be powered by a single General Electric F404-GE-F1G1 turbofan rated at 10,900 lb (4,836 kg) dry and 16,000 lb (7,260 kg) with afterburning. It will offer 45 per cent better acceleration, 34 per cent higher climb rate, a Mach=2.0 speed capability and nine per cent lower fuel consumption.

SPECIFICATION: F-5E Tiger II

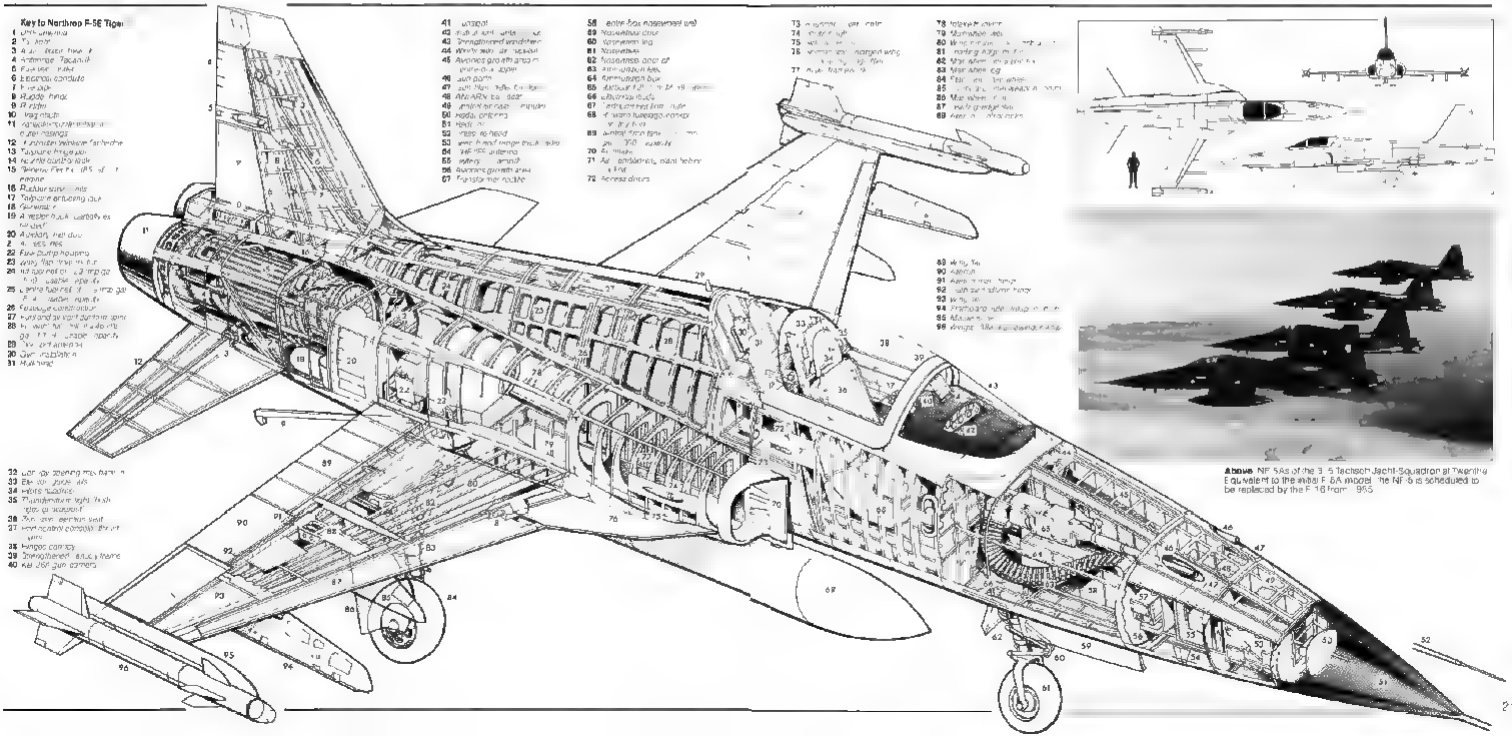
Power Plant: two General Electric J85-GE-21 turbojets each rated at 3,500 lb (1,587 kg) dry thrust and 5,000 lb (2,268 kg) with afterburning. Internal fuel capacity 550 Imp gal (2,500 l), with provision for one 220 Imp gal (1,000 l) centreline drop tank.

Performance: Max speed (50% internal fuel and two AIM-9J AAMs) 843 mph (1,357 km/h) or M=1.17 at sea level, 997 mph (1,605 km/h) or M=1.51 at 36,000 ft (11,000 m); initial climb 28,536 ft/min (145 m/sec); service ceiling 50,800 ft (15,400 m); combat radius (subsonic intercept with internal fuel only and two AIM-9Js) 317 mls (510 km) at (average) 548 mph (882 km/h) at 36,090-43,470 ft (11,000-13,250 m) (CAS) mission, Hi-Lo-Lo-Hi profile with drop tank, two AIM-9Js and four 500 lb (226·8 kg) MK 82 bombs), 294 mls (472 km); ferry range, 1,353 mls (2,177 km).

Weights: Empty, 9,588 lb (4,349 kg); combat, 14,558 lb (6,603 kg); max, 24,676 lb (11,193 kg).

Dimensions: Span, 26 ft 8 in (8,13 m); length (including probe), 48 ft 2 in (14·68 m); height, 13 ft 4 in (4,06 m); wing area, 186 sq ft (17,30 m²).

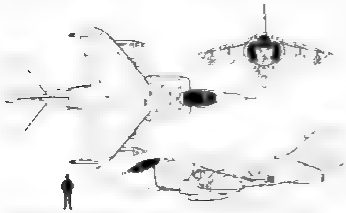
Armament: Two 20-mm M-39 cannon with 280 rpg and four or eight two AIM-9 Sidewinder AAMs, or up to 7,000 lb (3,175 kg) of external ordnance.



Above: NF-5As of the 3/5 Taktisch Jacht-Squadron at Twenthe. Equivalent to the initial F-5A model, the NF-5 is scheduled to be replaced by the F-16 from 1983.

British Aerospace Harrier (October 1980)

The increase in the generic usage of fighter as a classification and the parallel broadening of the fighter spectrum was to be reflected by two aircraft projects, the first practical applications of the most dramatic innovations since the advent of the turbojet, vertical and short take-off and landing (VTOL) and variable wing geometry. These were the Harrier and F-111, respectively, which were antithetical in concept and intended mission, one subsonic and optimised for the short-range, radius, ground attack task, the latter possessing twice the power and four times the weight, supersonic and suited for deep penetration counterair and interdiction missions. Yet both, by the terminology of the sixties, were fighters.



The Harrier was effectively an offshoot of the P.127, the first aircraft to offer VTOL by means of thrust vectoring. Radical yet basically simple conceptually, the P.127 rose vertically on the vectored thrust of an 11 000 lb (5 000 kg) Pegasus. Initially, on 21 October 1960, Nine pre-series aircraft (then known as Kestrel FGA Mk 1s) followed the six prototypes, and although re-engineered to cater for more power and to the production standard P.1127, RAF) named Harrier embodied no fundamental design changes. The first six (of 60) Harriers flew on 31 August 1966. 77 production Harrier GR Mk 1s were used as ground attack fighters. Capable of taking-off vertically at light weights, these early Harriers were for operational purposes, more realistically classed as short take-off and vertical landing (STOVL) aircraft.

The GR Mk 1s with 1 000 lb (454 kg) Pegasus 101 engines were progressively upgraded to GR Mk 3 (Pegasus 103) and then GR Mk 3 standards, a further 60 GR Mk 1s being built for the RAF and 102 similar aircraft as AV-8As for the US Marine Corps, plus 11 for the Spanish Navy. A navalised derivative, the Sea Harrier, is being built for the Royal Navy and Indian Navy and a proof-of-concept aircraft is being developed jointly by BAe and McDonnell Douglas as the Royal GR Mk 5 for the RAF and AV-8B for the USMC, the first full-scale development (AV-8B) aircraft having flown in late 1981.

SPECIFICATION: Harrier GR Mk 3

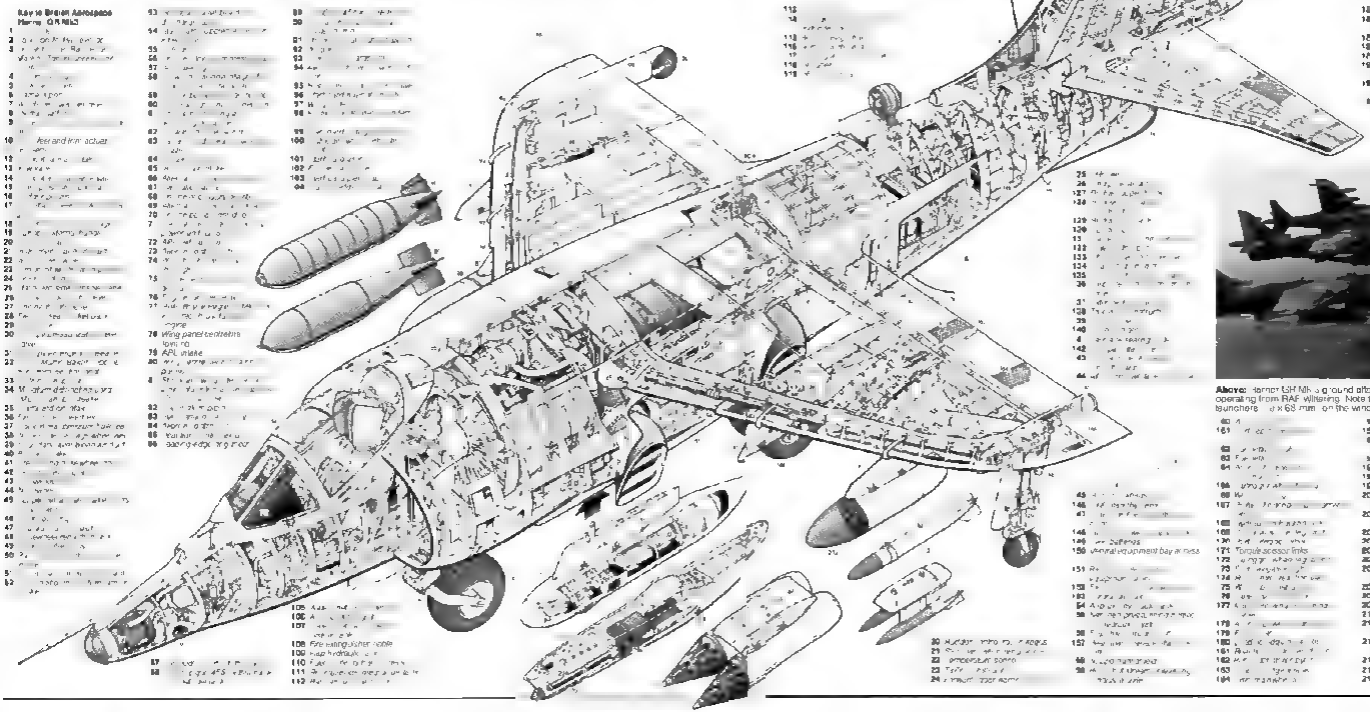
Power Plant One Rolls-Royce Pegasus 103 vectored-thrust turbofan rated at 21 500 lb (9 752 kg) dry thrust; internal fuel capacity 1 430 Imp gal (6 685 l), with provision for two 100 Imp gal (455 l) or (ferry) 330 Imp gal (1 500 l) drop tanks.

Performance. Max speed 730 mph (1 160 km h) or M=0.95 at 1 000 ft (305 m), 607 mph (977 km h) or M=0.92 at 36 000 ft (11 870 m); with typical ordnance load 575 mph (926 km h) or M=0.85 at sea level; tactical radius (ground attack off LO-LO-LO mission profile with 30 min loiter) 345 nm (397 mls, 640 km); with two 100 Imp gal (455 l) drop tanks and 1 500 lb (680 kg) external ordnance, 230 mls (370 km); (HI-LO-HI) 460 mls (740 km); ferry range, 2 070 mls (3 330 km); time to 40 000 ft (12 190 m) 2.8 min; service ceiling 48 000 ft (14 630 m).

Weights Empty 12 500 lb (5 670 kg); max (VTO) 18 000 lb (8 165 kg), (STO) 26 000 lb (11 794 kg).

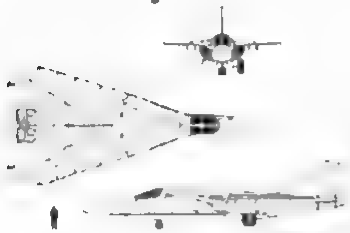
Dimensions Span, 25 ft 3 in (7.70 m); length 45 ft 7¾ in (13.91 m); height 11 ft 4 in (3.45 m); wing area, 201.1 sq ft (18.68 m²).

Armament Provision for two 30-mm Aden cannon with 130 rpg (supplemented after 1981 by two AIM-9 Sidewinder AAMs) and up to 5 000 lb (2 268 kg) of external ordnance.



Above: Harrier GR Mk 3 ground attack fighter operating from RAF Wittering. Note the rocket launchers and 68-mm rockets on the wing pylons.

General Dynamics F-111 (December 1964)



The fixed-geometry wing has always been at best a compromise and, before the fighter as a category had seen the end of its first decade, means were being sought of changing its wing geometry in flight. However, such polymorphs as did materialise were viewed as caprices of aeronautical design with little practical application and, in truth, they made no meaningful contribution to the variable-geometry (VG) wing as defined from the late 'forties, VG having become synonymous with variable sweep.

In highly swept, low aspect ratio configuration the VG wing promised low wave drag and a smooth ride in turbulence, with incidental benefits to structural fatigue life and, at the opposite end of its sweep range, low stalling and touchdown speeds, plus efficient subsonic cruise and loiter. The key to VG's practical application was provided by the NASA-conceived outboard hinge introduced by the F-111, this enabling the wing to translate through a full range of movement (16 to 72.5 deg) without affecting the aerodynamic centre and thus avoiding dangerous instability.

When the F-111A first flew, on 21 December 1964, VG was still a dubious novelty and the most controversial issue in the field of high-speed aviation. Embodying such ingenious features as a crew escape module and swivelling stores pylons, the F-111 was not the first VG fighter but it was the first to demonstrate the practicability of this radical development and the first VG fighter to attain production and service. Subjected to fierce political and technical controversy, the F-111 was to recover from its vicissitudes, but production was to end late 1973 with only 470 built, plus 76 of the FB-111A strategic bombing derivative, rather than the massive run of 1,700 plus originally envisaged.

SPECIFICATION F-111D

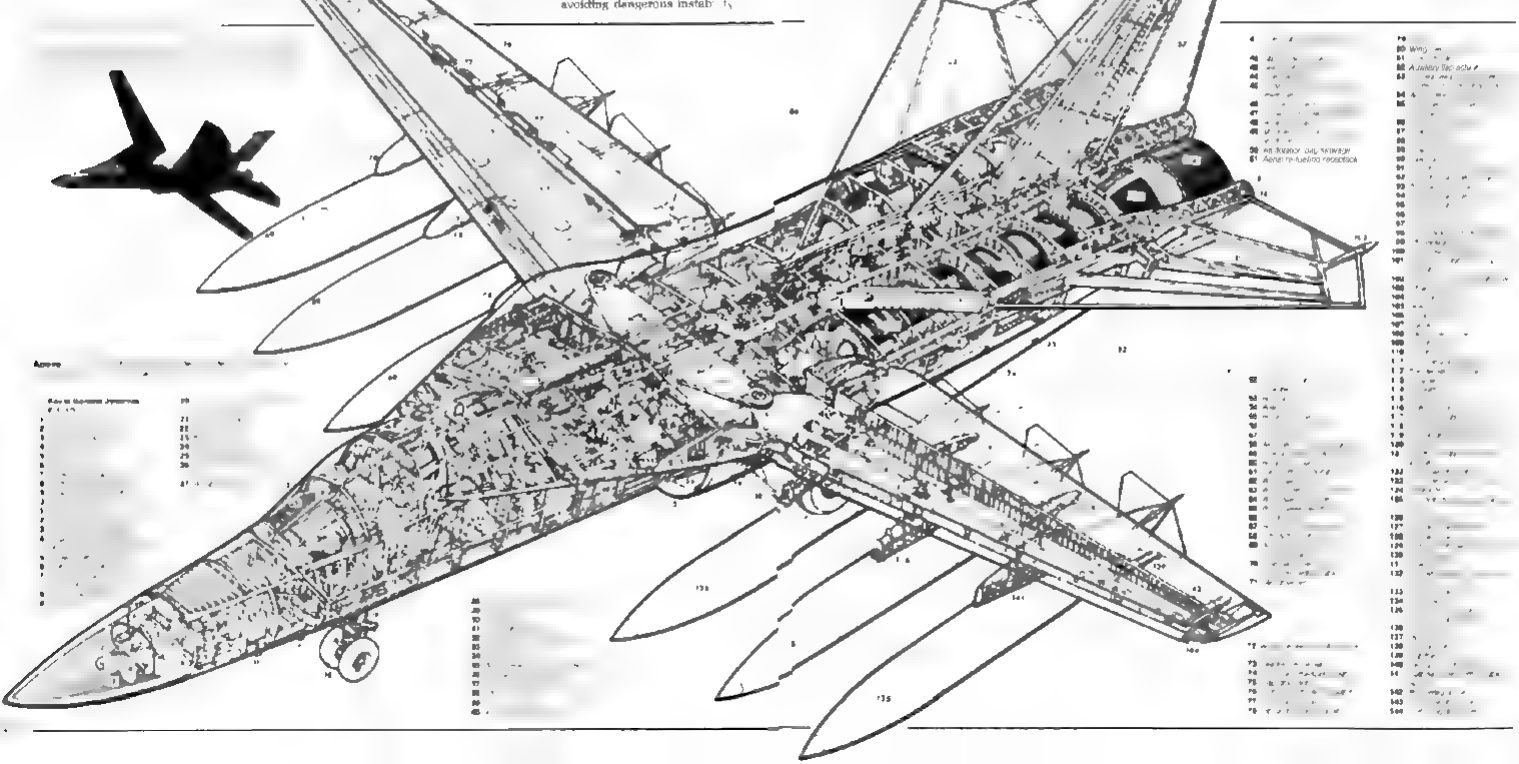
Power Plant: Two Pratt & Whitney TF30-P-9 turbofans each rated at 12,430 lb (5 638 kg) dry thrust and 20,840 lb (9 453 kg) with afterburning. Internal fuel capacity 4 199 imp gal (19 090 l) with provision for four 500 imp gal (2 273 l) drop tanks.

Performance. Max speed, 914 mph (1 471 km/h) or M=1.2 at sea level, 1 453 mph (2 338 km/h) or M=2.2 at 50,000 ft (15 270 m); max climb, 25 600 ft/min (131 m/sec); service ceiling, 53,400 ft (16 276 m); combat radius (Hi/LO-Hi mission profile on internal fuel, with one 2 000-lb, 907-kg bomb internally) 1,239 mls (1 985 km) at average 500 mph (805 km/h) at 32,400-35,700 ft (9 875-10 880 m), (LO-LO-Hi with two drop tanks), 921 mls (1 482 km), ferry range (internal fuel) 2,739 mls (4 408 km), (with two drop tanks), 3 698 mls (5 907 km).

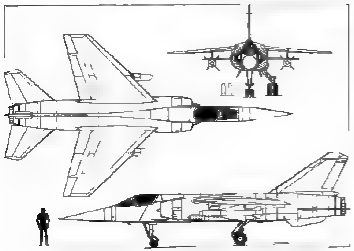
Weights. Empty 46 631 lb (21 152 kg); combat, 61 930 lb (28 091 kg); max, 100,000 lb (45 360 kg).

Dimensions: Span (wings extended) 63 ft 1 in (19.20 m), (max sweep), 31 ft 11¾ in (9.75 m); height 17 ft 0½ in (5.19 m); wing area 525 sq ft (48.77 m²).

Armament: Provision for one 20-mm M61A1 rotary cannon with 2 050 rounds in starboard weapons bay. Up to two 2 000-lb (907-kg) stores in weapons bays, or up to 25 000 lb (11 340 kg) external ordnance.



Dassault-Breguet Mirage F1 (December 1966)



As a result of parametric studies conducted in the early 'sixties and embracing all possible fighter configurations, Avions Marcel Dassault relinquished the tailless delta formula when choosing the form to be taken by the follow on to the Mirage III (see pages 212-213). Electing to revert to a more conventional arrangement of swept wing trimmed by a horizontal tail, Dassault retained the application of "Mirage" for the new warplane despite lack of family resemblance to its delta-winged predecessors other than a common design origin.

Designated Mirage F1, and flown as a prototype on 23 December 1966, the new fighter was similar in size to the Mirage III, but its thin swept wing afforded only some 72 per cent of the area of the latter's delta and had almost double the loading. Nevertheless, with the aid of leading- and trailing-edge flaps approach speed and landing run were reduced some 20 and 35 per cent respectively in comparison with the delta-winged fighter and agility at both subsonic and supersonic speeds was greatly enhanced. These improvements were achieved at some expense to wave drag and wing volume, but the loss in wing fuel capacity was more than compensated for by use of integral stowage rather than bag tanks, internal fuel capacity was actually increased by some 30 per cent as a result of this measure and the aircraft was a very much more flexible fighter than before.

The initial production version ordered for the Armée de l'Air the Mirage F1C flown on 15 February 1973 was optimised for a defence and air superiority missions with secondary ground attack capability. Maintaining the philosophy applied to the delta winged Mirage of evolving a simplified export model (Mirage 5) the Mirage F1A was developed for VFR operations on and to the ground attack role. In 1979, the Mirage F1C 200 began to enter French service, thus being endowed with long range reinforcement capability by means of a permanent flight refuelling probe, the Mirage F1CR (see page 1) coming into service in 1983. A total of 235 Mirage F1s in the various versions has been ordered for the Armée de l'Air and more than 400 had been ordered by 19 export customers by the beginning of 1982, with production of the aircraft thus being assured until the end of 1984.

SPECIFICATION: Mirage F1C

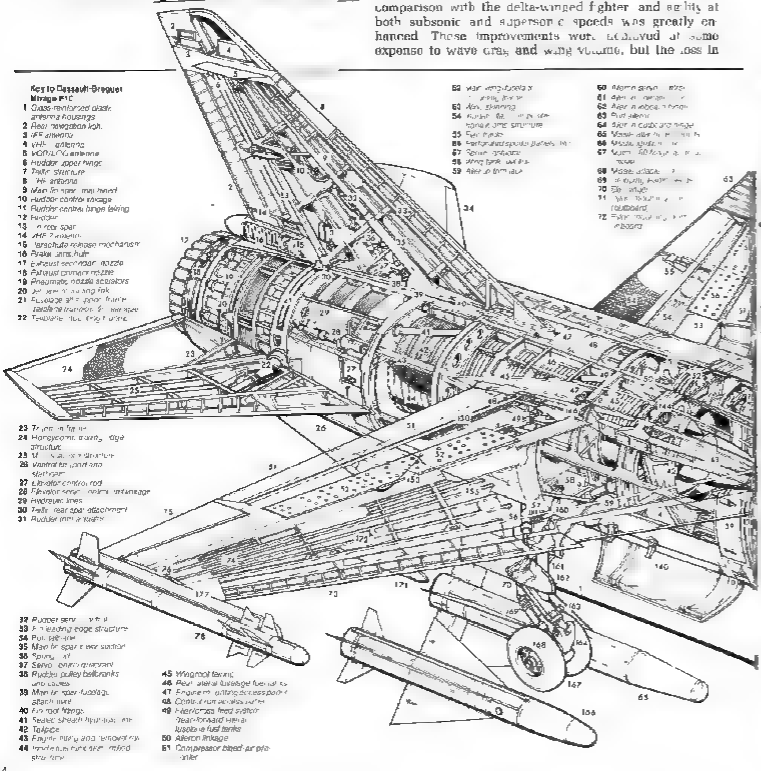
Power Plant. One SNECMA Atar 9K50 turbojet rated at 11,023 lb (5 000 kg) dry thrust and 15,873 lb (7 200 kg) with afterburning. Internal capacity, 940 Imp gal. (4 260 l), with provision for up to three 264 Imp gal. (1 200 l) drop tanks.

Performance Max speed, 913 mph (1 471 km/h) or M 1.2 at sea level, 1,401 mph (2 255 km/h) or M 2.2 at 39,370 ft (12 000 m); cruise 550 mph (885 km/h) at 29,530 ft (9 000 m); initial climb 4,930 ft/min (1,213 m/sec); service ceiling, 65,600 ft (20 000 m); combat radius (max external ordnance and HI-LO-LO-HI profile), 280 mls (448 km), (with two drop tanks and 4 440-lb (200-kg) bomb load) 670 mls (1 078 km); ferry range 2,050 mls (3 300 km).

Weights. Empty, 15 314 lb (7 400 kg); normal loaded 24 030 lb (10 900 kg); max 32,850 lb (14 900 kg).

Dimensions. Span 27 ft 1 in (8 40 m); length 49 ft 2 in (15.00 m); height, 14 ft 9 in (4.50 m); wing area, 269.1 sq ft.

Armament: Two 30 mm DEFA 553 cannon with 125 rpg and (interceptor mission) one to three Matra 550 Magic plus two AIM-9 Sidewinder AAMs or (ground attack) up to 8,818 lb (4 000 kg) of external ordnance.



Key to Dassault-Breguet Mirage F1C

1 Glass-reinforced plastic nosecone housings
2 Rear navigation light
3 UHF antenna
4 VHF/DF antenna
5 IFF antenna
6 Nodder upper hinge
7 Radar structure
8 Nodder lower hinge
9 Main fin root mounting
10 Rudder control linkage
11 Rudder cables hinge fairing
12 Nodder
13 Fin root spar
14 UHF 2 antenna
15 Jettisonable release mechanism
16 Brake parachute
17 Exhaust secondary nozzle
18 Exhaust primary nozzle
19 Pneumatic nozzle actuators
20 Jet pipe fin support ring
21 Fuselage skin/stringer frame (aft of pressure 6 bulkhead)
22 Tailplane hinge fairing frame
23 Tailplane fin
24 Honeycomb trailing edge structure
25 Tailplane control rod
26 Tailplane hinge/control linkage
27 Hydraulic lines
28 Tailplane root attachment
29 Rudder inner spar
30 Rudder rear spar attachment
31 Rudder inner spar
32 Rudder servo control
33 Fin leading edge structure
34 Pitot tube
35 Main fin spar/rear section
36 Spoiler
37 Servo control mechanism
38 Rudder pulley bellcranks and cables
39 Main fin rear fuselage attachment
40 Fin root fairing
41 Radar screen hydraulic jack
42 Tailplane
43 Fairing fitting and removal rail
44 Hydraulic fuel filler method stowage
45 Wing root fairing
46 Rear internal fuselage fuel tank
47 Engine air outlet access panel
48 Control run and cable
49 Hydraulic feed station rear forward limit
50 Aileron linkage
51 Compressor bleed air pipe
52 Wing root fairing
53 Aileron
54 Aileron hinge
55 Fuel feeds
56 Reinforced spoiler blades
57 Spoiler actuator
58 Wing tank outlets
59 Aileron trim tab
60 Aileron gland
61 Aileron hinge
62 Aileron actuator
63 Port aileron
64 Aileron cable and linkage
65 Wing skin/stringer
66 Wing skin/stringer
67 Wing root fairing
68 Wing skin
69 Wing skin
70 Flap actuator
71 Wing skin/stringer
72 Flap
73 Wing skin/stringer
74 Wing root fairing
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Below A Mirage F1 of the 10th Escadre de Chasse with its complement of Matra Magic and Sidewinder AAMs, and Matra 550 Magic

Saab 37 Viggen (February 1967)

The Swedish aerospace industry has displayed something of a predilection for the exotic in fighter configuration, following the unique double-delta Draken (see pages 208-209) with the equally unconventional close-coupled canard delta Viggen (Thunderbolt). Design of the Viggen which first flew on 8 February 1967 was heavily influenced by the demands of the Swedish quick-reaction and dispersal philosophy dictating emphasis on short field characteristics. The canard delta arrangement was considered to offer the best combination achievable with a fixed-geometry wing of high and low speed characteristics, low turbulence sensitivity, and efficient subsonic cruise and loiter capabilities. By selecting optimum location for the canard, or foreplane, which affords nose-up control and lift in its own right, the most favourable interaction with the mainplane was achieved. The powerful vortex from the canard surfaces generated a high speed airflow over the principal surfaces at low speeds, thus maintaining lift and permitting adoption of higher incidence angles.

The Viggen adhered to the 'standardised platform' concept, a basic design more or less readily adaptable to fulfil the four primary roles of attack, interception, reconnaissance and training, each mission-optimised version having a secondary role. The initial model, the AJ 37, was intended primarily for the attack mission but possessing a secondary interceptor capability the first of 110 production examples flying on 23 February 1971. Seventy similarly powered SF 37 and SH 37 reconnaissance aircraft and two-seat SK 37 trainers preceded the extensively re-engineered second generation JA 37 optimised for the air-air mission with secondary air-ground capability.

Featuring a more powerful engine and new systems and weaponry, the production JA 37 flew on 4 November 1977 following six R&D models, and entering Flygvapen service in 1980. Orders for 149 JA 37s have been placed with completion scheduled for 1985.

SPECIFICATION JA 37 Viggen

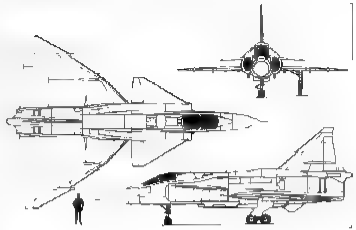
Power Plant: One Volvo Flygmotor RM 8B turbofan rated at 16 200 lb (7 350 kg) dry thrust and 28 110 lb (12 750 kg) with afterburning.

Performance: Max speed (with paired Rb 24 and Rb 71 AAMS) 838 mph (1 350 km/h) or M=1·1 at sea level, 1 225-1 365 mph (2 000-2 195 km/h) or M=1·9-2·1 at 36 090 ft (11 000 m); time from brakes off to 32 810 ft (10 000 m), 1·4 min; tactical radius (M=2·0 intercept mission), 250 mls (400 km), (counterair mission HI-LO-HI profile with centre-line drop tank and 3 000 lb 1 360 kg external ordnance), 650 mls (1 046 km), (LO-LO-LO with same external load) 300 mls (480 km).

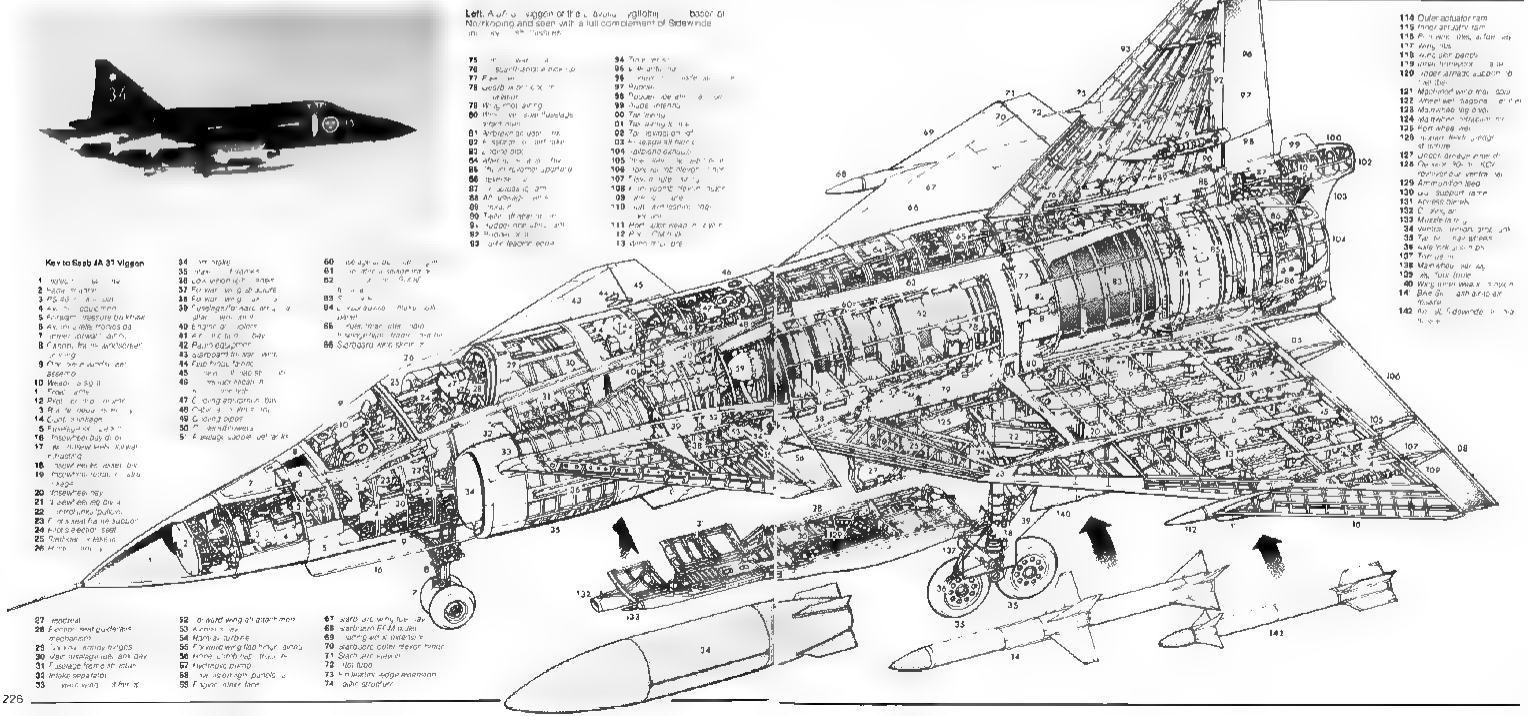
Weights: Empty (approx) 26 895 lb (12 200 kg); combat (cannon armament and half fuel), 33 070 lb (15 000 kg) with four AAMs), 37 040 lb (16 800 kg); max 49 600 lb (22 500 kg).

Dimensions: Span, 34 ft 9¾ in (10·60 m); length excluding probe), 50 ft 8¼ in (15·45 m); height 19 ft 4¼ in (5·90 m); total wing area (including foreplanes), 561·88 sq ft (52·20 m²).

Armament: One 30-mm Oerlikon KCA cannon with 150 rounds and (intercept) two Rb 71 Sky Flash and two or four Rb 24 Sidewinder air-to-air missiles, or (interdiction) 13 227 lb (6 000 kg) of ordnance mounted external to



Left: A JA 37 Viggen of the Swedish Air Force in flight. Above: Rear view of the Viggen showing the fin and rear fuselage with a full complement of Sidewinder missiles.



Key to Saab JA 37 Viggen

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2 Nose [illegible]
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5 Avionics [illegible]
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7 [illegible]
8 Canard [illegible]
9 [illegible]
10 Weapon [illegible]
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114 Outer actuator ram
115 Inner actuator ram
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120 Upper attack position [illegible]
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127 [illegible]
128 [illegible]
129 Ammunition feed
130 [illegible]
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133 Muzzle [illegible]
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Grumman F-14 Tomcat (December 1970)

Calling for a quantum advance in shipboard fighter capability, the US Navy's late 'sixties VFX requirement inevitably resulted in a variable-geometry aircraft. No fixed geometry configuration could fulfil the exacting speed, endurance and load carrying capabilities called for and meet deck-landing performance and shipboard stowage stipulations.

Above An F-14A Tomcat of US Navy VF-[illegible]

Equally inevitably, VFX was to be a formidably large and heavy fighter, and indeed, the F-14A in which the requirement resulted was to be the largest and heaviest aircraft in its category when it achieved service status in the second half of 1974.

First flown on 31 December 1970, the F-14A offered a capability that was undoubtedly nonpareil. It was the first and so far the only fighter with completely automatic sweep angle (20-68 deg) variation and possessed a unique multiple-target engagement faculty. Some 350 F-14As were in US Navy service in late 1981 when development included the enhanced TF30-PW-414A-engined F-14C for 1983 delivery with the existing F-14A fleet being modified to similar standards from the following year), and the General Electric F101-powered F-14D, introduction of which is called for in US Navy advanced planning after delivery of 605 Tomcats against a proposed total of 845.

SPECIFICATION F-14A Tomcat

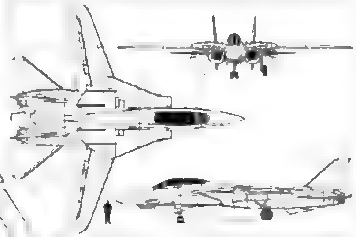
Power Plant: Two Pratt & Whitney TF30-P-412A turbofans each rated at 12 500 lb (5 670 kg) dry thrust and 20 900 lb (9 480 kg) with afterburning. Internal fuel capacity 1 969 Imp gal (8 951 l) with provision for two 222 Imp gal (1 008 l) drop tanks.

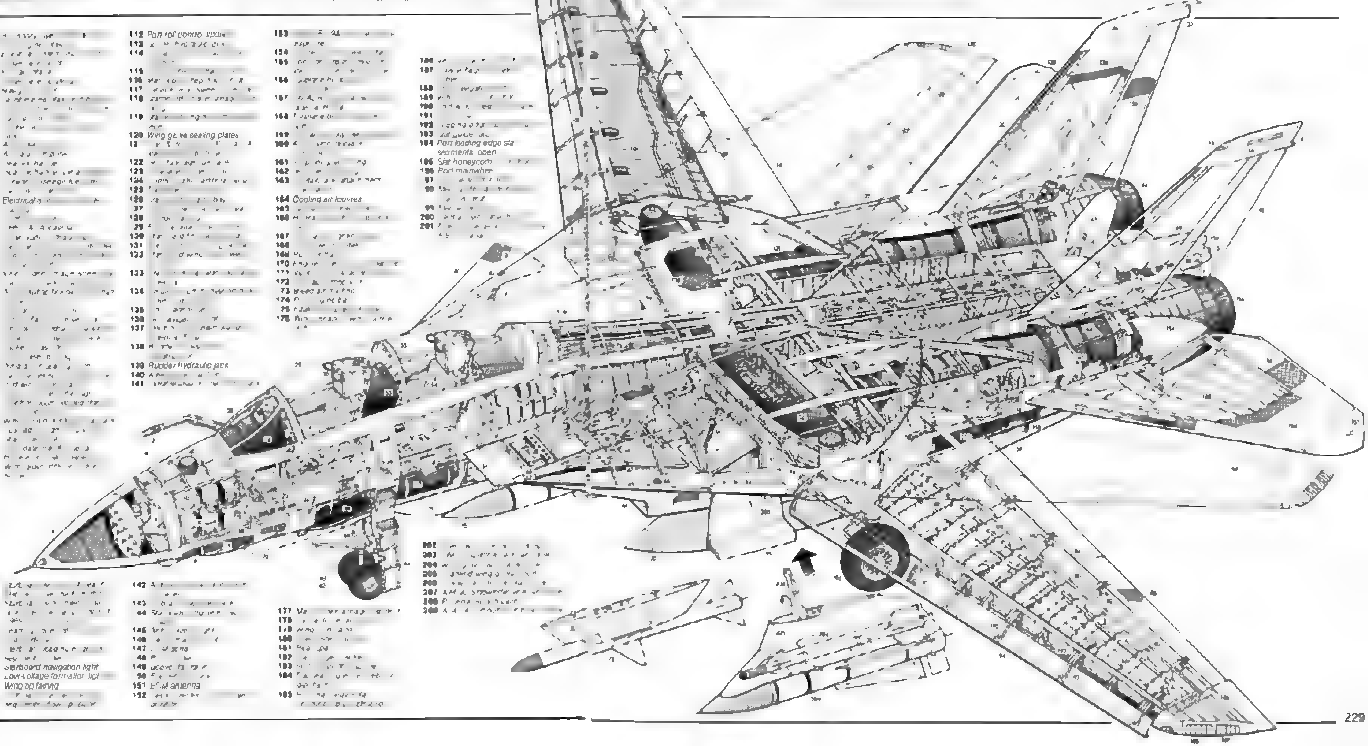
Performance: Max speed (with four semi-recessed AIM-7 AAMs) 919 mph (1 470 km/h) or M=1.2 at sea level, 1 584 mph (2 549 km/h) or M=2.4 at 49 000 ft (14 935 m). Time to 60,000 ft (18 290 m) at 55 000 lb (24 948 kg) 2.1 min. Tactical radius (interdiction mission on HI-LO-LO-HI profile with drop tanks and 14 MK 82 bombs), 725 mls (1 167 km). (combat air patrol internal fuel, six AIM-7 and four AIM-9 AAMs) 765 mls (1 232 km).

Weights: Empty, 39 930 lb (18 112 kg), loaded (intercept with four AIM-7s) 58 904 lb (26 718 kg) (with six AIM-54s) 66 790 lb (31 656 kg) combat air patrol 70,345 lb (31 908 kg) max, 74 348 lb (33 724 kg).

Dimensions: Span (wings extended) 64 ft 1½ in (19.55 m) (max sweep), 37 ft 7 in (11.45 m), (oversweep on deck) 33 ft 3½ in (10.15 m); length, 61 ft 11½ in (18.90 m), height, 16 ft 0 in (4.88 m), wing area, 565 sq ft (52.46 m²).

Armament: One 20-mm M-61A1 rotary cannon with 675 rounds and (intercept) six AIM-7E Sparrow and four AIM-9G Hi Sidewinder AAMs, or six AIM-54A Phoenix and two AIM-9G Hi AAMs, or (attack) various combinations of missiles and bombs up to 14,500 lb (6 577 kg).





McDonnell Douglas F-15 Eagle July 1972

Intimating re-emergence in the West of the optimised dogfighter after a lapse of many years, the Eagle, first flown on 27 July 1972, was essentially a fallout of Vietnam experience. The USAF had suffered an embarrassing inventory gap during that conflict which prompted the FX programme for a long-range air superiority fighter, a modern equivalent of the P-51 Mustang of WWII, and the Eagle was its end product. Featuring a very large, comparatively lightly loaded and essentially simple wing, which was to endow it with outstanding manoeuvrability, and a thrust-to-weight ratio at combat loadings well in excess of unity the Eagle proffered such a performance advance that, today, it remains unrivalled in its class.

The first production F-15A flew on 25 December 1974, the USAF attaining initial operational capability with the new fighter in July 1975. The F-15A and its two-seat equivalent, the F-15B were supplanted in production from mid 1980 (with 383 and 60 built respectively) by the F-15C and two-seat F-15D with increased internal fuel, provision for conformal tanks and enhanced avionics, these being the current models, with exports to Israel (75), Saudi Arabia (62) and Japan (14 plus 86 licence manufactured). However the design offers a flexible basis for development of versions for alternative roles, one such being the F-15E for long range interdiction and counterair missions.

Above [illegible]

SPECIFICATION: F-15C Eagle

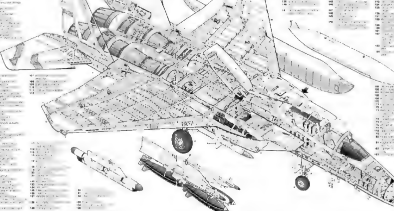
Power Plant: Two Pratt & Whitney F100-PW-100 turbofans each rated at 14,780 lb (6 705 kg) dry thrust and 23,904 lb (10 843 kg) with afterburning. Internal fuel capacity 1,724 Imp gal (7 837 l) with provision for two 710 Imp gal (3 228 l) in each of two conformal fuel pallets or three 500 Imp gal (2 273 l) drop tanks.

Performance: Max speed (short-endurance dash), 1,676 mph (2 697 km/h) or M=2.54 (sustained) 1,518 mph (2 443 km/h) or M=2.3 at 40,000 ft (12 192 m), 922 mph (1 484 km/h) or M=1.21 at sea level; max endurance (internal fuel) 2.9 hours (with conformal pallets), 5.25 hrs; ferry range (internal fuel), 1,950 mls (3 138 km), (with conformal pallets), 3,570 mls (5 745 km); ceiling 63,000 ft (19 200 m).

Weights: Basic 28,700 lb (13 018 kg), loaded (full internal fuel and four AIM-7 AAMs) 44,500 lb (20 185 kg), (plus three drop tanks), 57,400 lb (26 036 kg), max, 68,000 lb.

Dimensions: Span 42 ft 9¾ in (13,05 m), length 63 ft 9 in (19,43 m), height 18 ft 5½ in (5,63 m), wing area 608 sq ft (56,48 m²).

Armament: One 20-mm M-61A1 rotary cannon with 950 rounds and four AIM-7F Sparrow and four AIM-9L Sidewinder AAMs, or (secondary attack mission) up to 16,000 lb (7 258 kg) of external ordnance.



Key to McDonnell Douglas F-15C Eagle

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General Dynamics F-16 Fighting Falcon (January 1974)

Claimed with some justification to be the first in a new generation of advanced technology fighters, the F-16 is the first production aeroplane with full-time fly-by-wire (electrically-signalled) controls. It embodies automatically variable wing camber and some degree of artificial stability, and it features a blended-body fuselage design affording increased lift and internal volume. Reflecting a completely different design philosophy to that of the F-15 (see pages 230-231), the F-16 was nevertheless similarly conceived as essentially a dog fighter stemming from the USAF's LWF (Lightweight Fighter) programme. However, steady weight growth accompanying evolution from solely air-air to full multi-role capability has gone some way towards invalidating the original lightweight concept.

Flown as an aerodynamic prototype (YF-16) on 20 January 1974, it entered service with the USAF in its initial F-16A version in January 1979, and is the subject of a multinational manufacturing programme with final assembly lines in Belgium and the Netherlands. Illustrated by the accompanying drawings is the enlarged tailplane (to relax [illegible], increase the manoeuvre envelope with certain loads and reduce take-off speeds and abort distances) introduced from November 198

Above. An F-16A of the Belgian Air Force's 349° squadron which achieved

SPECIFICATION F-16A Fighting Falcon

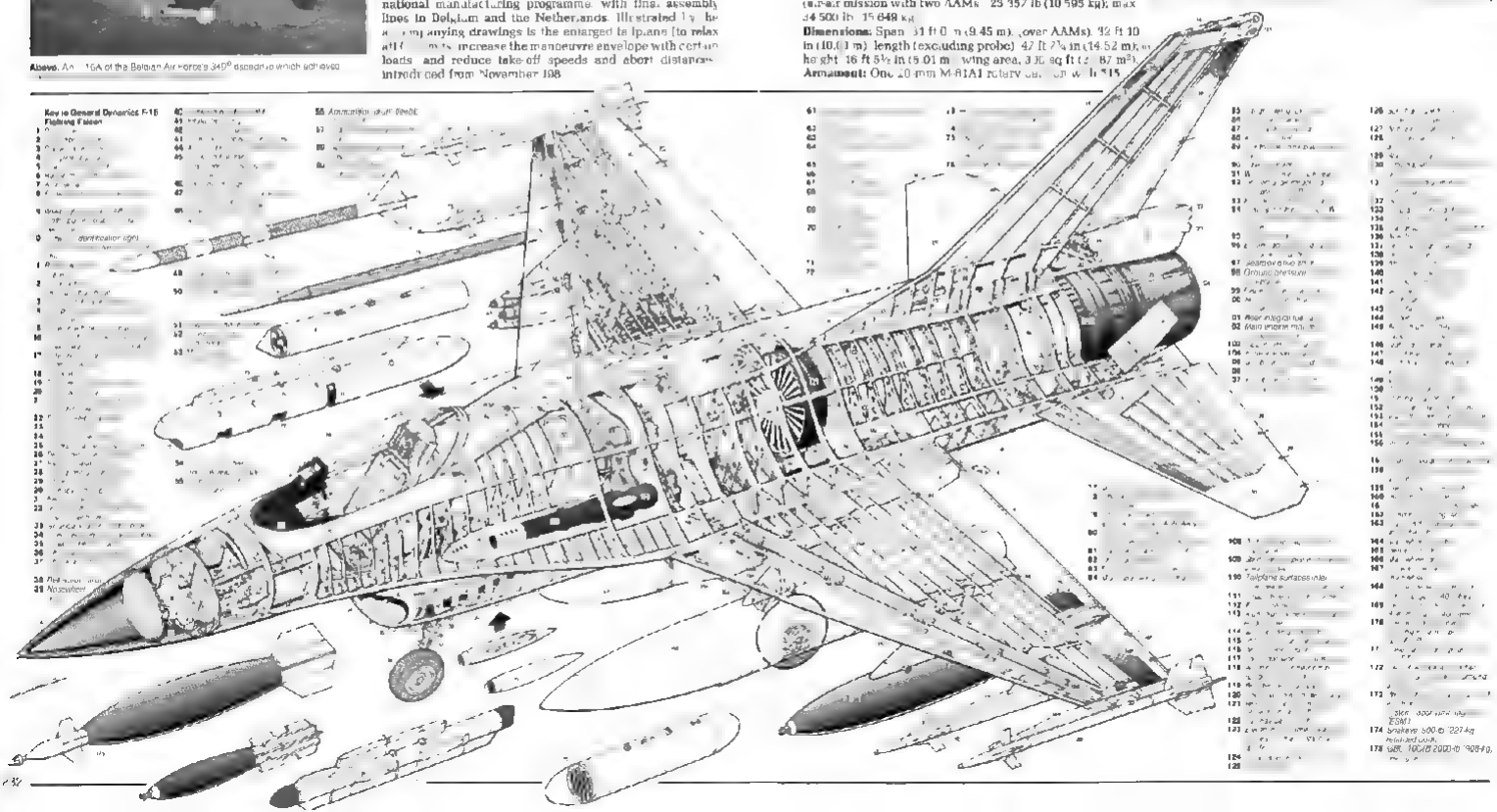
Power Plant: One Pratt & Whitney F100-PW-200 turbofan rated at 14,800 lb (6 713 kg) dry thrust and 23,830 lb (10 809 kg) with afterburning. Internal fuel capacity 893 Imp gal (4 060 l) with provision for one 250 Imp gal (1 136 l) centreline and two 308 Imp gal (1 400 l) wing drop tanks.

Performance: Max speed (short endurance dash), 1,333 mph (2 145 km/h) or M=2·02, (sustained), 1,247 mph (2 007 km/h) or M=1·89 at 40,000 ft (12 190 m); tactical radius (HI-LO-HI interdiction with 4 000 lb (1 814 kg) bomb load, internal fuel and 2 min allowance for combat), 360 mls (580 km); range (similar ordnance load and external fuel), 1,207 mls (1 930 km) at (average) 575 mph (925 km/h); ferry range (wing drop tanks), 2,535 mls (4 080 km).

Weights: Operational empty, 14,567 lb (6 608 kg); loaded (air-air mission with two AAMs), 23,357 lb (10 595 kg); max 34,500 lb (15 649 kg).

Dimensions: Span, 31 ft 0 in (9,45 m), (over AAMs), 32 ft 10 in (10,01 m); length (excluding probe), 47 ft 7¾ in (14,52 m); height, 16 ft 5¼ in (5,01 m); wing area, 300 sq ft (27,87 m²).

Armament: One 20-mm M-61A1 rotary cannon with 515 rounds and two-six AIM-9L/M Sidewinder AAMs. Provision for up to 12,000 lb (5 443 kg) ordnance.



Key to General Dynamics F-16 Fighting Falcon

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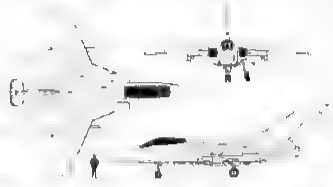
Panavia Tornado (August 1974)

The Tornado originated in a late sixties UK-German-Italian government agreement on joint development of a warplane then known as Multi-role Combat Aircraft (MRCA). The programme established final assembly lines in each country without component manufacture duplication.

The basic Tornado for tri-national use was optimised for interdiction and strike (IDS), the first prototype flying on 14 August 1974, with production aircraft delivered to the Tri-national Tornado Training Establishment at RAF Cottesmore in 1980. Planned deliveries to the RAF (200-220 Luftwaffe 212), Marineflieger (112) and Aeronautica Militare (100) are scheduled to be completed in 1986-87.

In addition to the IDS Tornado GR Mk 1, the RAF has a requirement for an air defence fighter version (ADV), the first prototype flying on 27 October 1979. Thus, the Tornado F Mk 2 (165-185 to be procured) emphasizes range and endurance for combat air patrols far from Britain's coasts where fighter opposition is unlikely, thus, dogfight capability tending to degrade performance as a bomber-destroyer need not be considered.

Retaining 80 per cent commonality with the GR Mk 1, the F Mk 2 features a redesigned nose for the intercept radar and a longer fuselage providing a 200 Imp gal (910 l) internal fuel increase and permitting mounting of four Sky Flash missiles. Increased fuselage fineness ratio results in some gain in supersonic efficiency and extension of the fixed wing glove to compensate for the CG change produces a modest drag reduction. Deliveries will commence in 1983, with initial operational capability being achieved in 1984.



SPECIFICATION Tornado F Mk 2

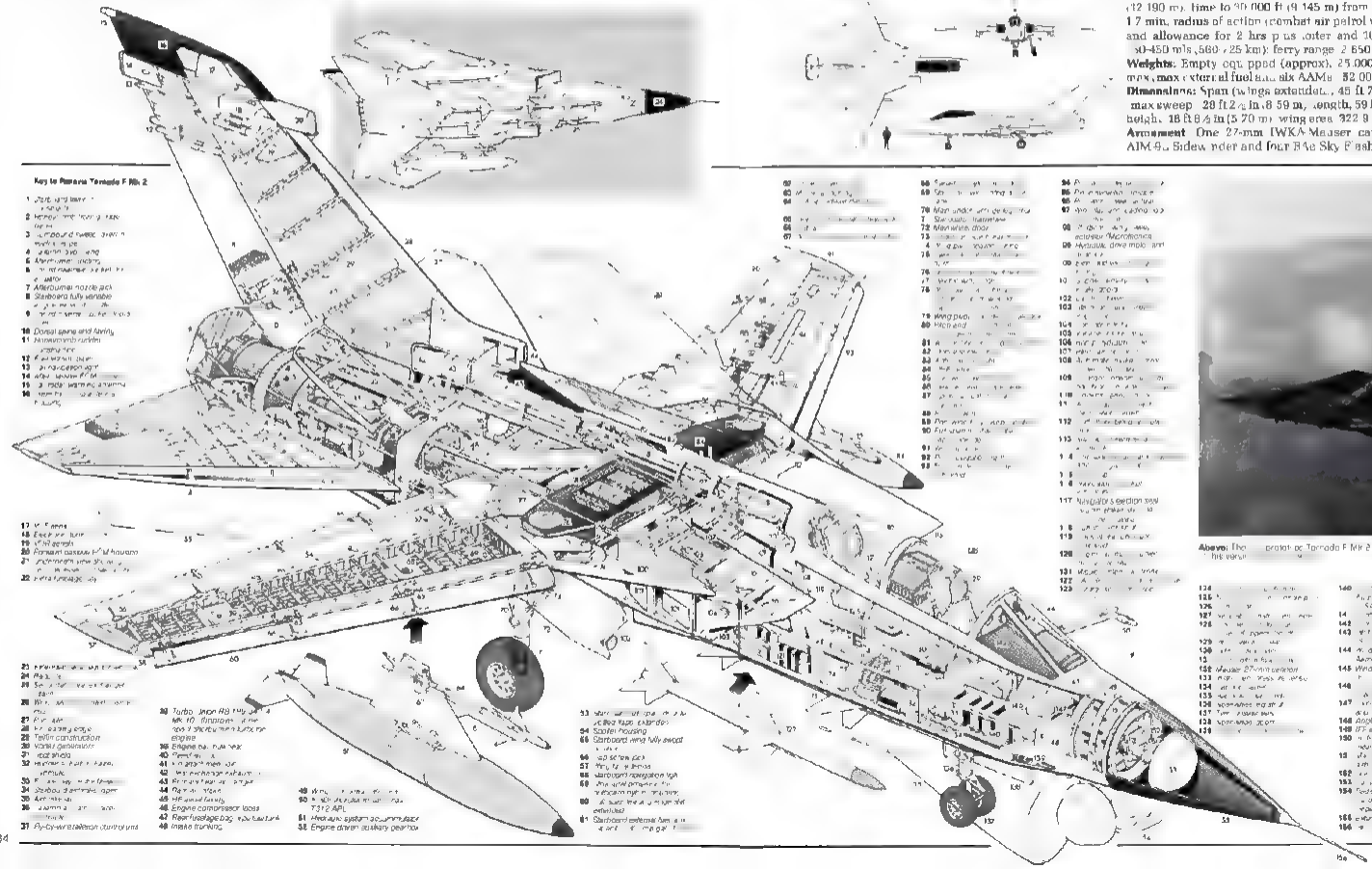
Power Plant: Two Turbo-Union RB.199-34R-04 Mk 1, 1 (improved) turbofans each rated at (approx) 9 000 lb (4 082 kg) dry thrust and (approx) 16 000 lb (7 258 kg) with afterburning. Internal fuel capacity (approx) 1 600 Imp gal (7 274 l) with provision for two 330 Imp gal (1 500 l) drop tanks.

Performance: Max speed, 920 mph (1 480 km h) or M = 1 2 at sea level, 1 450 mph (2 333 km h) or M = 2 2 at 40,000 ft (12 190 m), time to 30 000 ft (9 145 m) from brakes release, 1 7 min, radius of action (combat air patrol with drop tanks and allowance for 2 hrs plus loiter and 10 min combat), 450-450 mls (560-725 km); ferry range 2 650 mls (4 265 km).

Weights: Empty equipped (approx), 25 000 lb (11 340 kg) max, max external fuel and six AAMs, 52 000 lb (23 587 kg).

Dimensions: Span (wings extended), 45 ft 7½ in (13 90 m), max sweep 28 ft 2½ in (8 59 m), length, 59 ft 9 in (18 06 m), height, 18 ft 8¾ in (5 70 m), wing area 322 9 sq ft (30 00 m²).

Armament: One 27-mm IWKA-Mauser cannon, and two AIM-9L Sidewinder and four BAe Sky Flash AAMs.



Above: The prototype Tornado F Mk 2 at the Farnborough show

Dassault-Breguet Mirage 2000 (March 1978)

Although it was widely believed that the delta had provided merely an interim solution to the problems of building a supersonic wing and was passé by the mid 'sixties, Dassault-Breguet was induced by advances in control technology to revert to this formula for its third-generation Mirage. This, the Mirage 2000, first flew on 10 March 1978, and was configurationally similar to the first-generation Mirage III (see pages 212-213), but it exploited negative longitudinal stability and thus removed the principal shortcomings previously inherent in the tailless delta.

Traditionally, the maximum lift coefficient of the conventional stable delta is small and its trim drag high. If the centre of gravity (CG) is moved aft of the aerodynamic centre (AC), the delta becomes longitudinally unstable, but at high angles of attack, as in manoeuvring flight or landing, an aerodynamic upload on the elevons improves both trimmed lift coefficient and trim drag. The advent of electrically-signalled (fly-by-wire) controls in combination with an advanced automatic flight control system had rendered such highly unstable aircraft flyable.

Refined by computer-aided design to give a highly optimised shape, the Mirage 2000 could be flown with substantial instability, the lift gain being as much as 25 per cent over the conventional stable delta, automatic leading-edge flaps permitting safe operation up to high angles of attack. With an internal fuel capacity representing approximately 30 per cent of the clean take-off weight—a percentage previously attained only by certain US Navy fighters—and a highly effective nav-attack system with a radar range more than twice that of the Mirage F1, the Mirage 2000 will represent a quantum capability advance when it enters Armée de l'Air service in its initial single-seat air superiority version in 1984.

Single-seat attack and two-seat low-level penetration versions are also under development, prototypes of the latter, the Mirage 2000N (Nucléaire), being scheduled for flight test in 1983. From 1985 onwards, the M53-5 turbofan is to give place to the M53-P with military and afterburning ratings of 14,330 lb (6 500 kg) and 21,385 lb (9 700 kg).

SPECIFICATION: Mirage 2000

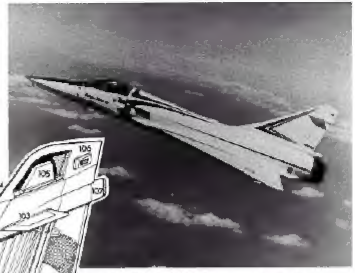
Power Plant: One SNECMA M53-5 turbofan rated at 12,345 lb (5 600 kg) dry thrust and 19,840 lb (9 000 kg) with afterburning. Internal fuel capacity, 835 Imp gal (3 800 l), with provision for one 264 Imp gal (1 200 l) centreline and two 374 Imp gal (1 700 l) underwing drop tanks.

Performance: Max speed, 915 mph (1 472 km/h) or M=1·2 at sea level, 1,550 mph (2 495 km/h) or M=2·35 above 36,090 ft (11 000 m); max climb rate, 49,000 ft/min (249 m/sec); service ceiling, 65,000 ft (19 800 m); time to 49,200 ft (15 000 m) and M=2·0, 4·0 min; combat radius (intercept mission with two 374 Imp gal/1 700 l drop tanks and four AAMs), 435 mls (700 km); ferry range, 2,420 mls (3 900 km).

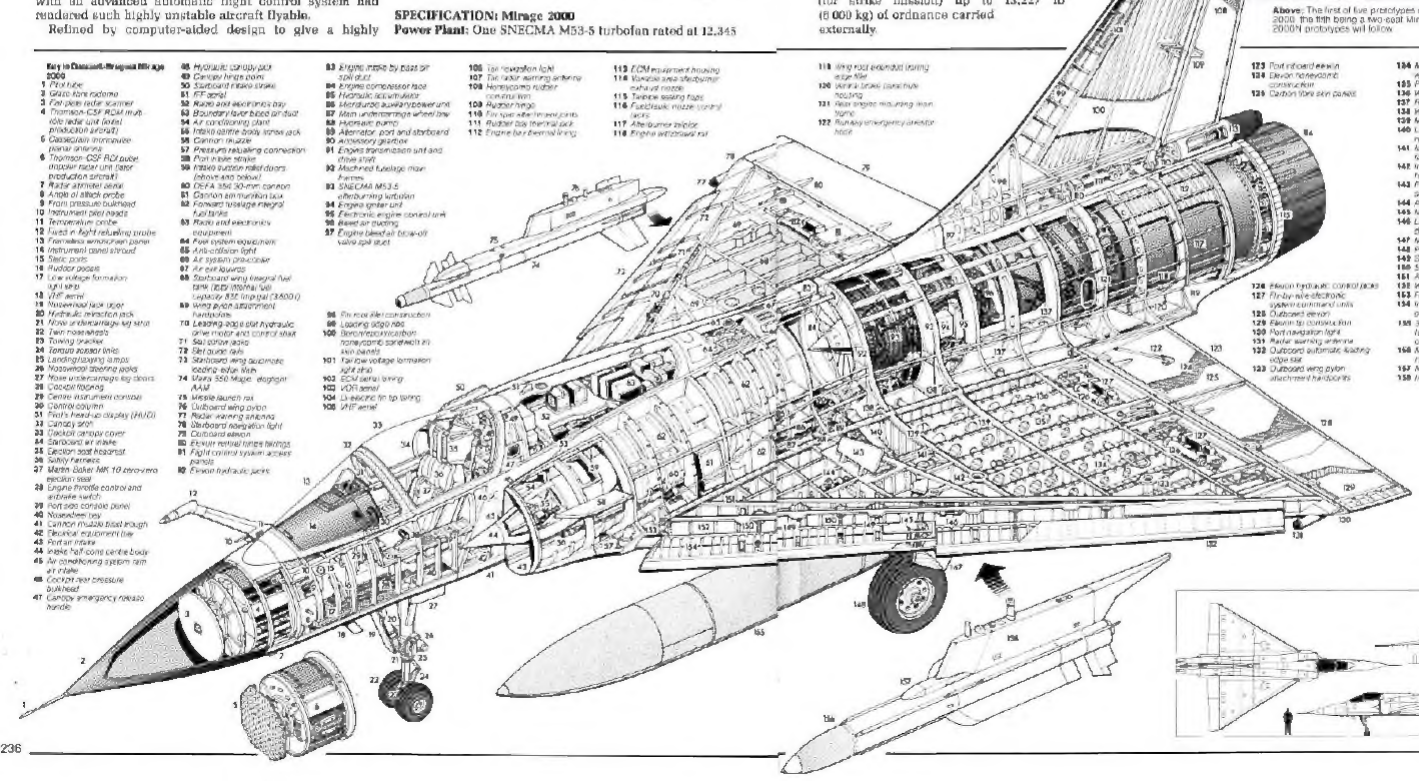
Weights: Combat loaded, 19,840 lb (9 000 kg); max, 33,070 lb (15 000 kg).

Dimensions: Span, 29 ft 8½ in (9.00 m); length 50 ft 3½ in (15.33 m); wing area, 441·3 sq ft (41.00 m²).

Armament: Two 30-mm DEFA 554 cannon and (air superiority mission) two Matra 550 Magic and two Matra Super 530D air-to-air missiles, or (for strike mission) up to 13,227 lb (6 000 kg) of ordnance carried externally.

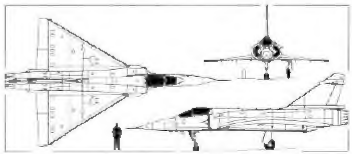


Above: The first of five prototypes of the Mirage 2000. The fifth being a two-seat Mirage 2000B. Two Mirage 2000N prototypes will follow.



Key to Dassault-Breguet Mirage 2000

1 Pitot tube
2 Glass fibre radome
3 Fan plate radar scanner
4 Thomson-CSF RDM multi-role radar unit (pulse production aircraft)
5 Cassegrain monopulse planar antenna
6 Thomson-CSF RDI pulse Doppler radar unit (later production aircraft)
7 Radar altimeter aerial
8 Angle of attack probe
9 Front pressure bulkhead
10 Instrument panel shield
11 Temperature probe
12 Fixed in flight refuelling probe
13 Frameless windscreen panel
14 Instrument panel shroud
15 Static ports
16 Rudder pedals
17 Low voltage formation light strip
18 UHF aerial
19 Nosewheel tank door
20 Hydraulic retraction jack
21 Nose undercarriage leg strut
22 Twin nosewheels
23 Towing bracket
24 Torque scissor links
25 Landing/taxying lamps
26 Nosewheel steering jacks
27 Nose undercarriage leg doors
28 Cockpit floorpan
29 Centre instrument console
30 Control column
31 Pilot's head-up display (HUD)
32 Canopy arch
33 Cockpit canopy cover
34 Starboard air intake
35 Ejection seat headrest
36 Safety harness
37 Martin Baker MK 10 zero-zero ejection seat
38 Engine throttle control and airbrake switch
39 Port side console panel
40 Nosewheel bay
41 Cannon muzzle blast trough
42 Electrical equipment bay
43 Port air intake
44 Intake half-cone centre body
45 Air conditioning system ram air intake
46 Cockpit rear pressure bulkhead
47 Canopy emergency release handle
48 Hydraulic canopy jack
49 Canopy hinge point
50 Starboard intake duct
51 IFF aerial
52 Radio and electronics bay
53 Equipment layer based on dual 54 Air conditioning plant
55 Intake centre body strut jack
56 Cannon muzzle
57 Pressure refuelling connection
58 Port intake strake
59 Intake suction relief doors (above and below)
60 DEFA 554 30-mm cannon
61 Cannon ammunition box
62 Forward fuselage integral fuel tanks
63 Radio and electronics equipment
64 Fuel system equipment
65 Anti-collision light
66 Air system precooler
67 Air exit louvres
68 Starboard wing integral fuel tank (EFS (Ventral) fuel capacity 835 Imp gal (3800 l))
69 Wing pylon attachment hardpoints
70 Leading-edge slat hydraulic drive motor and control shaft
71 Slat stroke jacks
72 Slat guide rails
73 Starboard wing automatic leading-edge slat
74 Matra 550 Magic dogfight AAM
75 Missile launch rail
76 Outboard wing pylon
77 Radar warning antenna
78 Starboard navigation light
79 Outboard aileron
80 Elevon retract torque fittings
81 Flight control system actuator panels
82 Elevon hydraulic jacks
83 Engine intake by-pass air spill duct
84 Engine compressor face
85 Hydraulic accumulator
86 Mechanical auxiliary power unit
87 Main undercarriage wheel bay
88 Hydraulic pumps
89 Alternator, port and starboard
90 Accessory gearbox
91 Engine transmission unit and drive shaft
92 Machined fuselage main frames
93 SNECMA M53-5 afterburning turbofan
94 Engine igniter unit
95 Electronic engine control unit
96 Bleed air ducting
97 Engine bleed air blow-off valve spill duct
98 Fin root skin construction
99 Loading cargo rail
100 Boron/epoxy/titanium honeycomb sandwich fin skin panels
101 Tail low voltage formation light strip
102 ECM aerial fairing
103 VOR aerial
104 Underfin tip fairing
105 UHF aerial
106 Tail navigation light
107 Tail radar warning antenna
108 Honeycomb rudder construction
109 Rudder hinge
110 Fin root attachment points
111 Rudder bias thermal jack
112 Engine bay thermal lining
113 ECM equipment housing
114 Variable area afterburner exhaust nozzle
115 Twelve seating flats
116 Fuselaxis nozzle control jacks
117 Afterburner jetpipe
118 Engine anti-shock rail
119 Wing root extended fairing
120 Wing fillet
121 Aileron hydraulic actuator housing
122 Port engine mounting main frame
123 Runway emergency arresting hook
124 Port inboard aileron
125 Elevon honeycomb construction
126 Carbon fibre skin panels
127 Fly-by-wire electronic system command units
128 Outboard elevon
129 Elevon tip construction
130 Port navigation light
131 Radar warning antenna
132 Outboard automatic leading-edge slat
133 Outboard wing pylon attachment hardpoints
134 Machined upper and lower wing skin/stringer panels
135 Port wing integral fuel tank
136 Wing rib construction
137 Rear fuselage/wing root
138 Wing spar attachment joints
139 Main spars
140 Undercarriage hydraulic retraction jack
141 Main undercarriage leg pivot fairing
142 Inboard pylon attachment hardpoints
143 Port airbrake (open) above and between wing
144 Airbrake hydraulic jack
145 Main undercarriage leg strut
146 Leading edge slat hydraulic drive motor
147 Main wheel leg door
148 Port mainwheel
149 Slat guide rails
150 Slat stroke jacks
151 Auxiliary spar
152 Wing root spar
153 Front spar attachment joint
154 Inboard automatic leading-edge slat no construction
155 375 Imp gal (1 700 l) ventral fuel tank (fuselage centreline or wing inboard stations)
156 Matra "Super 530" medium-range AAM
157 Missile launch rail
158 Inboard wing pylon



McDonnell Douglas F-18 Hornet (November 1978)

Above: Four F-18A Hornets of the US Navy's Air Test and Development Squadron VX-4 at Point Mugu which has responsibility for the initial service trials of the new multirole fighter.

Intended to integrate air superiority and attack functions within a common and comparatively inexpensive airframe, the F-18 Hornet shipboard fighter is derived from the Northrop YF-17 technology demonstrator lightweight fighter. Like the YF-17, the F-18 features a so-called hybrid wing with leading edge extensions increasing maximum lift by some 50 per cent, and reducing both lift-attributable drag and, by acting as a compression wedge, the Mach number at the engine intake face.

Retaining little more than the basic aerodynamic form of its progenitor, the F-18 is some 12 per cent larger overall, primarily to cater for a 70 per cent increase in internal fuel, and has been re-engineered throughout. Possessing automatic leading and trailing edge manoeuvring flaps, the F-18 is the first production aircraft with a digital (as opposed to analogue) fly-by-wire control system backed up by mechanical reversion on the tailscon controls.

Two essentially similar but optimised versions are planned for air superiority (F-18) and attack (A-18), but full-scale production of only the former has so far been authorised, the US Navy having requested approval for procurement of 867 F-18As and two-seat TF-18As during 1981-86. A shore-based version of the F-18A has been ordered by Canada which is to receive 113 single- (CF-18A) and 24 two-seat (CF-18B) Hornets from late 1982.

SPECIFICATION: F-18A Hornet

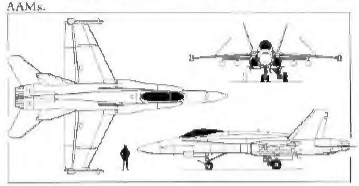
Power Plant: Two General Electric F404-GE-400 turbofans each rated at (approx) 10,800 lb (4 810 kg) dry thrust and 15,800 lb (7 167 kg) with afterburning. Internal fuel capacity, 1,390 Imp gal (6 319 l) and provision for three 262 Imp gal (1 192 l) drop tanks.

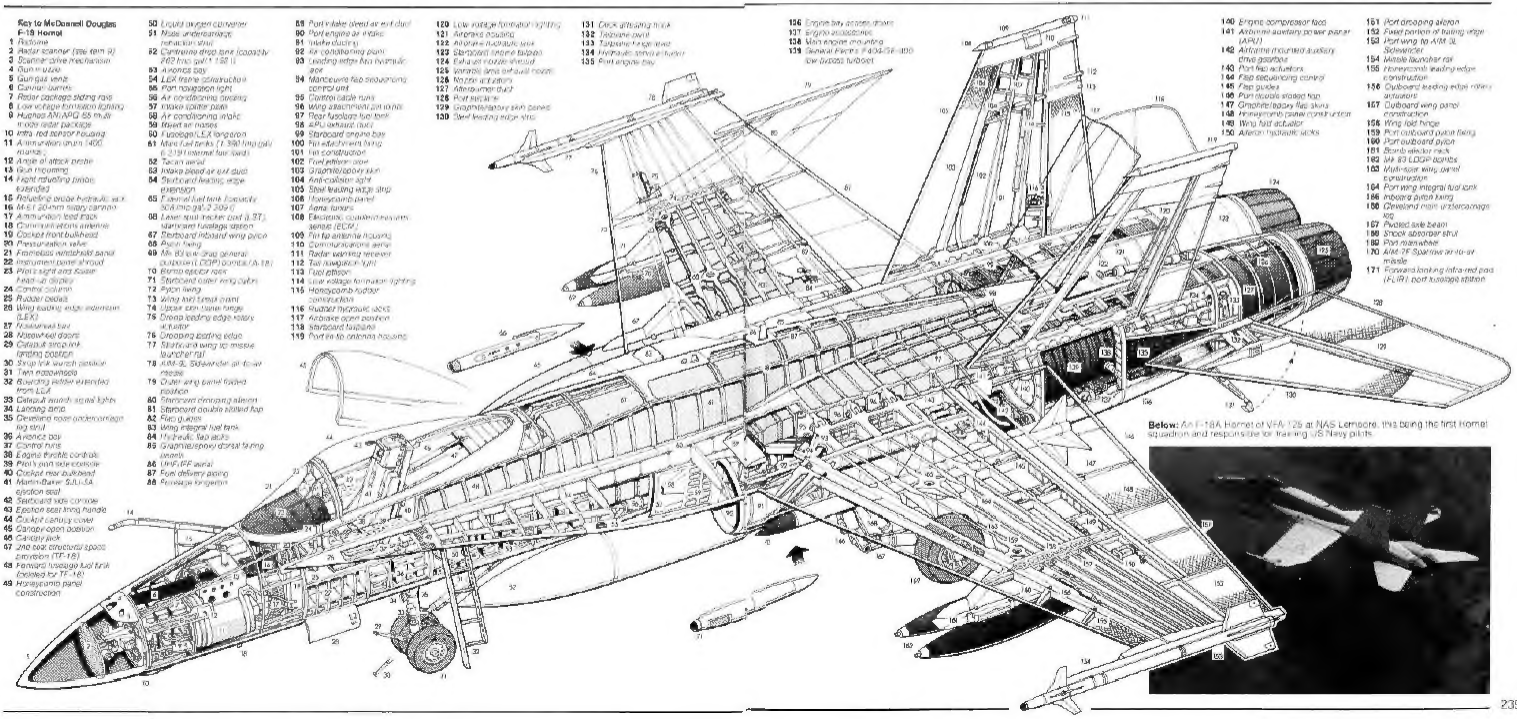
Performance: Max speed, 915 mph (1 472 km/h) or M=1·2 at sea level, 1,190 mph (1 915 km/h) or M=1·8 at 40,000 ft (12 192 m); initial climb (half fuel and two AIM-9 AAMs), 60,000 ft/min (304.8 m/sec); acceleration from M=0·8 to M=1·6 at 35,000 ft (10 670 m), 1·8 min; radius (combat air patrol mission on internal fuel), 480 mls (770 km), (with three drop tanks), 740 mls (1 190 km); ferry range, 2,875 mls (4 627 km).

Weights: Empty equipped, 28,000 lb (12 700 kg); loaded (air superiority mission with half fuel and four AAMs), 35,800 lb (16,240 kg), (attack mission with full internal fuel and 7,500 lb/3 400 kg ordnance), 47,000 lb (21 315 kg); max, 56,000 lb (25 400 kg).

Dimensions: Span, 37 ft 8 in (11.43 m); length 56 ft 0 in (17.07 m); height, 15 ft 4 in (4.67 m); wing area, 396 sq ft. (36.79 m²).

Armament: One 20-mm M-61A1 rotary cannon with 570 rounds and (air-air) two AIM-7E/F and two AIM-9G/H AAMs.





Key to McDonnell Douglas F-18 Hornet

1 Radome
2 Radar scanner (see item 9)
3 Scanner drive mechanism
4 Gun muzzle
5 Gun gas vents
6 Cannon barrels
7 Radar package sliding rails
8 Low-voltage formation lighting
9 Hughes AN/APG-65 multi-mode radar package
10 Infra-red sensor housing
11 Ammunition drum (400 rounds)
12 Angle of attack probe
13 Gun mounting
14 Flight refuelling probe, extended
15 Refuelling probe hydraulic jack
16 M-61 20-mm rotary cannon
17 Ammunition feed track
18 Communications antennae
19 Cockpit front bulkhead
20 Pressurisation valve
21 Frameless windshield panel
22 Instrument panel shroud
23 Pilot's sight and Kaiser head-up display
24 Control column
25 Rudder pedals
26 Wing leading edge extension (LEX)
27 Nosewheel bay
28 Nosewheel doors
29 Catapult strop link grating position
30 Strop link launch position
31 Twin nosewheels
32 Rudder pedals extended from LEX
33 Catapult launch signal lights
34 Landing arms
35 Cleveland nose undercarriage leg strut
36 Avionics bay
37 Control rods
38 Engine throttle controls
39 Port main side console
40 Cockpit rear bulkhead
41 Martin-Baker S.J.U.5A ejection seat
42 Starboard side console
43 Ejection seat firing handle
44 Cockpit canopy cover
45 Canopy open position
46 Canopy jack
47 2nd seat structural space provision (TF-18)
48 Forward fuselage fuel tank (added for TF-18)
49 Honeycomb panel construction
50 Liquid oxygen container
51 Main undercarriage retraction strut
52 Centreline drop tank (capacity 262 Imp gal/1 192 l)
53 Avionics bay
54 LEX frame construction
55 Port navigation light
56 Air conditioning cooling
57 Intake boundary layer
58 Air conditioning inlet
59 Nose air nozzles
60 Fuselage/LEX longeron
61 Main fuel tanks (1,390 Imp gal/6 319 l internal fuel load)
62 Tacan aerial
63 Intake bleed air exit duct
64 Starboard leading edge extension
65 Internal fuel tank (capacity 308 Imp gal/1 2 200 l)
66 Laser spot tracker pod (LST) stanchion fuselage station
67 Starboard inboard wing pylon
68 Pylon fairing
69 Mk 83 low drag general purpose (LDGP) bomb (A-18)
70 Bomb ejector rack
71 Starboard outer wing pylon
72 Pylon fairing
73 Wing fold break point
74 Upper spin tunnel hinge
75 Drooping leading edge rotary actuator
76 Drooping leading edge
77 Starboard wing tip missile launcher rail
78 AIM-9L Sidewinder air-to-air missile
79 Outer wing panel folded position
80 Starboard drooping aileron
81 Starboard double slotted flap
82 Fairings
83 Wing integral fuel tank
84 Hydraulic flap jacks
85 Graphite/epoxy dorsal fairing panels
86 UHF/IFF aerial
87 Fuel delivery piping
88 Fuselage longeron
89 Port intake bleed air exit duct
90 Port engine air intake
91 Intake duct ring
92 Air conditioning plant
93 Leading edge flap hydraulic jack
94 Manoeuvre flap actuating compound
95 Control cable runs
96 Wing attachment pin joints
97 Rear fuselage fuel tank
98 APU exhaust duct
99 Starboard engine bay
100 Tail attachment fairing
101 Fin construction
102 Fuel pipework
103 Graphite/epoxy skin
104 Anti-collision light
105 Steel leading edge strip
106 Honeycomb panel
107 Aerial runners
108 Electronic countermeasures sensor (ECM)
109 Fin tip antenna housing
110 Communications aerial
111 Radar warning receiver
112 Tail navigation light
113 Fuel pipework
114 Low voltage formation lighting
115 Honeycomb rudder construction
116 Rudder hydraulic jacks
117 Airbrake open position
118 Starboard tailplane
119 Port fin tip antenna housing
120 Low voltage formation lighting
121 Airbrake double
122 Airbrake hydraulic jack
123 Starboard inboard flap
124 Exhaust nozzle shroud
125 Variable area exhaust nozzle
126 Nozzle actuators
127 Afterburner duct
128 Port tailplane
129 Graphite/epoxy skin panels
130 Steel leading edge strip
131 Deck arresting hook
132 Tailplane pivot
133 Tailplane hinge line
134 Hydraulic servo actuator
135 Port engine bay
136 Engine bay access doors
137 Engine accessories
138 Main engine mounting
139 General Electric F404-GE-400 low bypass turbofan
140 Engine compressor face
141 Airborne auxiliary power plant (APU)
142 Airframe mounted accessory drive gearbox
143 Port fan actuators
144 Fan sequencing control
145 Fan guides
146 Port double slotted flap
147 Graphite/epoxy flap skins
148 Honeycomb panel construction
149 Wing fold actuator
150 Aileron hydraulic jacks
151 Port drooping aileron
152 Fixed portion of trailing edge
153 Port wing to AIM-9L Sidewinder
154 Missile launcher rail
155 Honeycomb leading edge construction
156 Outboard leading edge rotary actuators
157 Outboard wing panel construction
158 Wing fold hinge
159 Port outboard pylon fairing
160 Port outboard pylon
161 Bomb ejector rack
162 Mk 83 LDGP bombs
163 Multispar wing panel construction
164 Port wing integral fuel tank
165 Inboard pylon fairing
166 Cleveland main undercarriage leg
167 Pivoted axle beam
168 Shock absorber strut
169 Port nosewheel
170 AIM-7F Sparrow air-to-air missile
171 Forward looking infra-red pod (FLIR), port fuselage station

Below: An F-18A Hornet of VFA-125 at NAS Lemoore, this being the first Hornet squadron and responsible for training US Navy pilots.

Index of Aircraft Types

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